Engineering News

Vol. 67, No. 13 505 Pearl Street, New York March 28, 1912

Description of the Prosser Division of the Sunnyside Unit, Yakima Project, United States Reclamation Service

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The Yakima Project of the U. S. Reclamation Service is located in the well known Yakima Valley in the State of Washington. The Sunnyside Unit of this project begins about 10 miles in a southeasterly direction from the City of North Yakima and extends along the Yakima River for a distance of about 50 miles. The whole unit contemplates the irrigation of about 100,000 acres of land of which 60,000 acres are already being supplied with water. The present paper deals with the construction of a portion of this unit consisting of about 2500 acres, which is really a small project in itself, as it involves practically all kinds of irrigation construction.

The Prosser Division

This area is located south of the Yakima River and extends east and west from the town of Prosser as indicated on the accompanying map, Fig. 1. The various features involved in the construction of this system are shown on the map. Beginning at the diversion from the Sunnyside main canal the water is first allowed to run down a natural watercourse a distance of about one-half mile. It is then diverted from this watercourse into an artificial earth channel about 400 ft. long called "feeder canal," at the end of which it is taken into a 30½-in. diameter reinforced-concrete pipe, 2825 ft. long; then into a 31-in. wood-stave pipe, 7500 ft. long, which is carried across the Yakima River on a steel bridge; then run again into a 30½-in. concrete pipe for about 275 ft. to a reinforced-concrete standpipe outlet. At this point the water is discharged into a semicircular steel flume, of 5 ft. diameter, 1000 ft. long, and is then divided into the east and west distributaries, from which the deliveries to the land are made. The distribution of the water on the lands involved an unusual quantity of flumes, chutes and pipes. These structures were all made of wood, machine-banded wood-stave pipes being used for all pipe deliveries.

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Structures

The structures will be described in the order of their succession from the main canal down. Those on the distribution system are all small and of standard type and only general mention is made of them.

The turnout from the main canal into the natural channel is made through a wooden chute, the main canal itself being carried across this channel in a wood flume. The quantity of water diverted is 26 c.f.s. The channel, having a very steep slope, required no treatment other than the removal of some large stones and vegetable growths in order to carry this quantity without the formation of ponds. The diversion from this watercourse into the feeder canal is made by means of a concrete cut-off wall founded on bedrock, provided with a spillway for natural drainage waters. This cut-off wall diverts the irrigation water through an opening in a concrete head-wall, provided with flashboard control for keeping the flood waters from entering the pipe when the system is not in operation. The intake to the pipe is a simple concrete structure, of which a photograph is shown in Fig. 2.

Steel Flumes from Concrete-pipe Conduit to Distributaries at Prosser

Concrete Pipe

Description.—The concrete pipe, as well as all other concrete structures, was built by force account. The type of pipe used and the methods of construction are similar to those used on the Umatilla Project of the U. S. Reclamation Service, described in Engineering News, Vol. 65, page 208. The forms used, however, were different, and a two-segment collar instead of three-segment was used for the joints. The sections of pipe were made 6 ft. long, each section weighing about 1500 lb. The inside diameter was 30½ in., and the thickness of shell 2½ in. The Chezy formula was used for determining the size of pipe required. The value of n used was 0.013. The profile, Fig. 3, shows the pressure to which the pipe is subjected.

Manufacture.—The pipe sections were manufactured in a central pipe yard at Prosser and hauled to the line in wagons, the average distance being about 1½ miles. Views of the pipe yard are shown in Figs. 4 and 5. The location of this manufacturing plant was ideal, being just below a siding on the Northern Pacific Ry., which is located on a high fill. The gravel used had to be shipped in by rail from a point about 25 miles west. The bins were built at the toe of the fill, thus making a very simple arrangement for unloading as well as having the gravel in the bins at the proper elevation for convenient supply to the mixer. Electric light and water for mixing and sprinkling were supplied from the city plant. The concrete was carried from the mixer to the forms in wheelbarrows. It was deposited in the top of the 6-ft. form, a platform about 3 ft. from the ground being used to facilitate pouring and tamping, which was done

with round rods and narrow flat slotted spades.

FORMS—Twenty steel forms were used. These were made in the Reclamation Service shop at Sunnyside at a cost of $108 each.

The details of the form are shown in Fig. 6. In order to insure a perfect cylinder the patterns for the semi-circular rings were first made in the Reclamation Service shop; these were sent to a foundry at North Yakima and rough castings cade. By comparison of the castings with the patterns the amount of shrinkage was determined. On the basis of this information the patterns were modified and the final rings were cast from these. The machine work was all done in the shop at Sunnyside, a special lathe having been set up for the purpose. The steel sheets were cut and riveted by hand. The inside form was made in three pieces, divided vertically, and the outside in four pieces, being divided vertically and horizontally at the middle. All parts were light enough so one man could handle them. The outer form was originally divided into two parts vertically to facilitate pouring the concrete and to avoid excessive tamping, it having been the intention to build up the lower half of the outside form first, pour this, and then build up the upper half, thus avoiding having to lift all the concrete 6 ft. Experience, however, showed that it was more economical and just as satisfactory to build up the entire form in one operation and pour it all from the top. It would, therefore, be better to have the upper and lower half of the outside form riveted together, as these could be handled in this shape with equal facility and could be set up more rapidly.

REINFORCEMENT—The reinforcement of No. 4 wire was wound into coils on a reel similar to the method used on the Umatilla Project already referred to.

The reinforcement was designed for a working stress of 12,000 lb. per sq.in., and the maximum head on the concrete pipe is about 50 ft. Three different spacings of the No. 4 wire were used: 1¾, 2½ and 3½ in.

LAYING—The method of laying is clearly shown in Fig. 8. A chain block attached to the apex of a three-legged frame was used for lifting the pipe and swinging it into place. In laying the pipe the collar segments were first set to line and grade. Only one man was required for this work. The pipe layers then followed up and set the pipe carefully on these segments. A man was kept on the inside of the pipe to line up the ends and mortar the joint. The pipe gang was followed up by collar setters who put on the other half of the collar and completed the joint. The laying of this pipe proved to be a very simple matter, and was quickly, accurately and cheaply done.

CONCRETE AND AGGREGATE — River gravel was used for the aggregate. On account of the thinness of the shell and the relatively large amount of space taken up by the reinforcement, the gravel had to be screened through a ¾-in. square-mesh screen. All the material passing this screen was used; 4.7 sacks of cement were used to each cubic yard of gravel and it required 1.2 cu.yd. of gravel to make a cubic yard of concrete. This mixture gave very satisfactory results, both in the manufacture of the pipe and in its behavior in the completed structures.

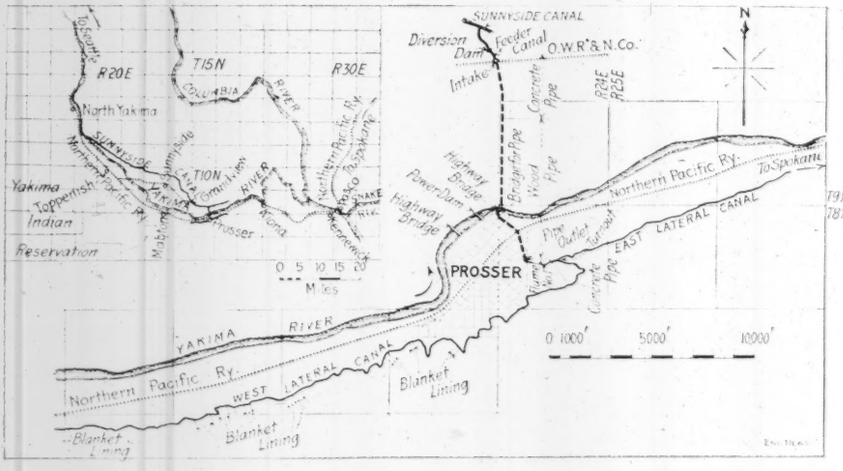


FIG. 1. LOCATION MAP, PROSSER DIVISION OF SUNNYSIDE UNIT OF YAKIMA PROJECT, U. S. RECLAMATION SERVICE

OPERATION—The pipe has been in operation under almost full pressure for about three months at the time of this writing and no leaks have developed except one hole evidently blown through the pipe by some malicious person with a rifle before

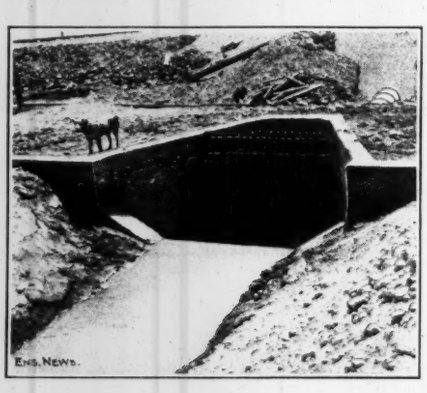


FIG. 2. INTAKE OF CONCRETE PIPE, UNDER O.-W. R. & N. ROADBED

any backfilling was made and before the pipe at this point had been subjected to more than a few feet pressure. When water was first turned into the pipe small leaks developed at practically all the joints and seepage through the body showed up at many points. All this, however, disappeared in a few days and all leakage stopped without any treatment. This was probably accomplished principally by the silting up of the interstices by material carried by the water, which was heavily charged with silt.

WOOD-STAVE PIPE

The reason for using two radically different kinds of pipe on a single line may not be apparent. The explanation is that it was desired to operate the wood pipe under a minimum head of 20 ft., as experience elsewhere had shown that wood pipe could not be well preserved under lower heads than this even if always kept full of water. The wood pipe was therefore terminated at such points that when the pipe was full and just overflowing at the outlet the static head at the ends of the wood pipe would be not less than 20 ft. This will be the condition between irrigation seasons, when the pipe will not be in operation and when it is expected to keep it full of water from a nearby pumping plant. Under these conditions the entire pipe line is practically a permanent structure. It was calculated that this construction was more economical than building the entire line of concrete, especially as it was important to keep the first cost as low as possible consistent with fairly permanent construction.

DESCRIPTION—The wood pipe is of the continuous-stave type, 7500 ft. long and 31 in. in diameter. The staves are 2 in. thick and the bands ⅞ in. diameter with malleable-iron shoes designed and manufactured especially for this pipe. In determining the size of the pipe a special formula, based on experiments, was used, as this was considered a safer basis than an assumed value of Kutter's *n* in the Chezy formula.

CONSTRUCTION — The construction of this pipe will be described in greater detail than may perhaps seem necessary, as very little has been published in regard to methods and appliances used in the construction of wood-stave pipes. Although simple, this is a highly specialized art and

there are comparatively few engineers or others thoroughly acquainted with it. In spite of the fact that timber is getting more scarce each year and proper material for pipes is becoming increasingly difficult to obtain, the writer believes that the popularity of this form of construction is increasing rather than diminishing. Used as in the present instance, there can be no serious question as to its economy and efficiency.

The method of constructing a wood-stave pipe of this size is briefly as follows: A piece of iron tubing, bent in the form of a semicircle of diameter slightly larger than the required outside diameter of the pipe, is used for laying up the staves and holding them to the shape in the lower half. The upper half section of staves are then laid on a similar tube bent to a radius slightly less than that of the interior of the pipe. While the bands are being placed on the outside the staves are hammered out from the inside and made flush with one another. A space of from 3 to 4 ft. is always left between ends of adjoining staves. Before the succeeding set of staves is placed the projecting staves are pried apart and the tongues inserted in the slots. The tongues are usually made of No. 11 or No. 12 gage steel and about 1 to 1½ in. wide, depending on the size of pipe, and of a length about ⅛ in. greater than the width of the stave so that they crush about ½ in. into the adjoining staves. After the tongues have all been placed the next set of staves is placed and the rounding-out process is repeated. In driving the staves the tension on the bands is so adjusted that usually the second joint back is the one driven home. This is not a simple adjustment to make and requires considerable practice in order to obtain the desired results. It often happens when the adjustment of bands or method of driving is not proper that the adjoining staves, which have been driven home, will rebound and open up the joint again, or that the next succeeding joint which has been driven home in the previous set will open up slightly. These items can be learned by experience only. After the pipe erection has been completed the final cinching of the bands is done just before water is turned into the pipe.

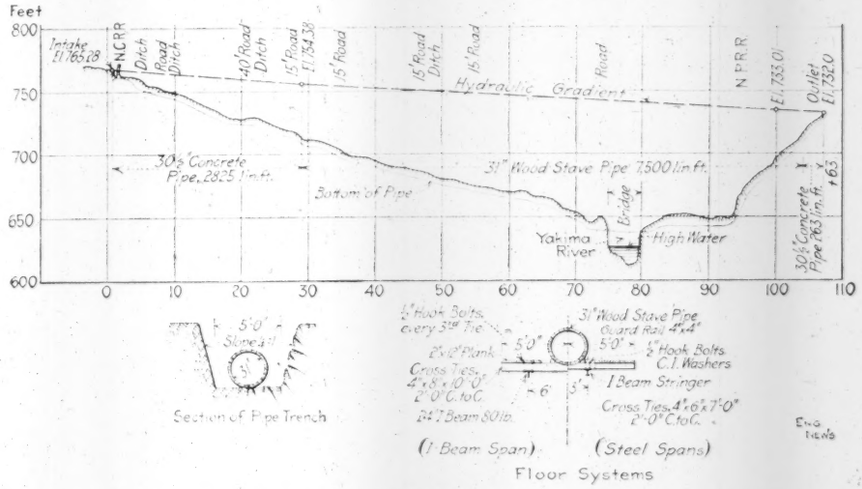


FIG. 3. PROFILE OF PIPE LINE, PROSSER IRRIGATION WORKS

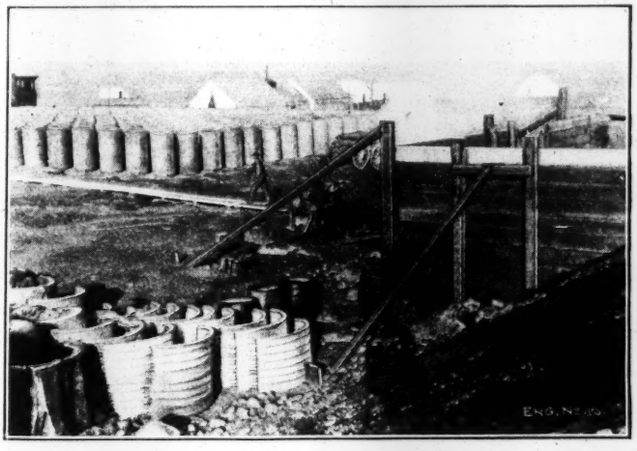


FIG. 4. VIEW IN PIPE YARD, SHOWING FINISHED CONCRETE PIPE AND COLLARS

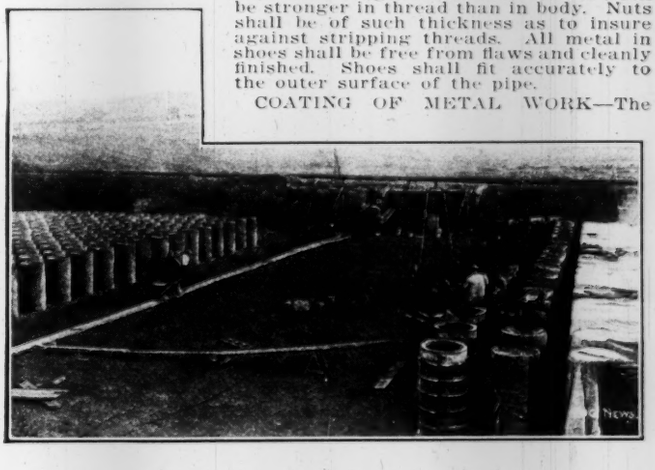


FIG. 5. VIEW OF PIPE MANUFACTURING PLANT

SPECIFICATIONS—To afford an indication of the quality of work required on this pipe the following extracts are made from the specifications covering the same:

DIAMETER OF PIPE—The inside diameter of the pipe shall be 31 in., measured after completion of the work. No diameter shall differ more than ¼ in. from the normal diameter of pipe, and the average diameter of the pipe at any point shall not be less than 31 in. nor more than 31½ in.

STAVES—All lumber used in staves shall be yellow fir (Douglas fir). It shall be sound, straight-grained, and free from dry rot, pitch seams, pitch pockets, checks, wind shakes, sapwood or other imperfections that may impair its strength or durability. No through knots or knots on the edges or at ends of staves shall be permitted. Sound knots not exceeding ½ in. in diameter not falling within the above limitations nor exceeding more than three within a 10-ft. length will be accepted. All lumber used shall be seasoned by not less than 60 days' air drying in open piles before milling, or by kiln drying. All staves shall be accurately planed to a smooth surface to fit a standard pattern provided by the contractor. Staves shall be trimmed perfectly square at ends and slots for tongues shall be in exactly the same relative position for all ends and according to detail drawings furnished by the contractor. Staves shall be of an average length of 16 ft. or upward. No staves shorter than 10 ft. will be accepted. The finished thickness of staves shall be not less than 2 in. All staves delivered on the work in a bruised or injured condition will be rejected.

METAL WORK—All bands shall be of ½-in. diameter mild steel. Shoes shall be of malleable iron or steel and shall have the dimensions shown in drawing. There shall be one shoe to each band. Steel used for bands shall have the following qualities: Tensile strength, from 55,000 to 65,000 lb. per sq.in.; elastic limit, as determined by the drop of the beam, of not less than one-half the ultimate tensile strength; minimum per cent. of ultimate elongation in 8 in. of 1,400,000 divided by the ultimate tensile strength; and capability of being bent flat upon itself when cold without fracture. Bands shall have button heads of dimensions shown on drawing. Threads shall permit the nut to run freely for the entire length of thread. Bands shall be stronger in thread than in body. Nuts shall be of such thickness as to insure against stripping threads. All metal in shoes shall be free from flaws and cleanly finished. Shoes shall fit accurately to the outer surface of the pipe.

COATING OF METAL WORK—The bands and shoes shall be coated by being dipped when hot into a mixture of pure California asphalt, or equivalent, and linseed oil. This coating shall be so proportioned and applied that it will form a thick and tough coating, free from tendency to flow when exposed to sunshine or to become brittle when cold.

TONGUES—Tongues shall be of either steel or oak. If of steel they shall be flat, ⅛ in. thick. The width shall be such that when in place they will penetrate into the sides of adjacent staves without undue injury. The tongues and slots shall be so proportioned as to insure a tight fit of the tongues into the slots without danger of splitting the staves.

ERECTION—The pipe shall be built in a workmanlike manner. The ends of staves shall break joint at least 3 ft. Staves shall be driven in such a manner as to avoid any tendency to cause wind in pipe. Staves shall be well driven to produce tight butt joints, driving bars or other suitable means being used to avoid marring or damaging staves in driving. In rounding out the pipe, care shall be exercised to avoid damage by chisels, mauls or other tools. The pipe shall be rounded out to produce smooth inner and outer surfaces. Bands shall be accurately spaced and placed perpendicular to the axis of the pipe. Shoes shall be placed to cover longitudinal joints between staves and bear equally on two staves. They shall be placed alternately on opposite sides of the pipe so as to be out of line and cover successively on each side at least three joints. Bands shall be spaced in accordance with detailed lists to be furnished and as staked on the ground, the following schedule being an indication of the total number required. They shall be hammered thoroughly into the wood to secure a bearing of 60° of the circumference. All kinks in bands shall be carefully hammered out, and bands shall be back-cinched to the satisfaction of the engineer so as to produce satisfactory initial compressive stresses in the staves. All metal work shall be handled with reasonable care so as to avoid injury to the coating as much as possible. After erection the contractor shall have the coating of all metal work, where abraded, thoroughly retouched with an asphaltum paint satisfactory to the engineer.

RESULTS ATTAINED—After completion, and after the pipe had attained its final swell, two diameters at right angles to each other were measured at intervals of 50 ft. over the full length of the pipe. The average of all diameters thus measured was 31.03 in. The smallest diameter measured was 30⅜ in., and the largest diameter was 31⅝ in. The smallest average diameter found at any section was 30⅝ in., and the largest was 31⅜ in. The greatest difference between the two diameters measured at any section was found to be ⅝ in.

The stave material used was in every respect equal to the specifications. During the work the inspector rejected staves amounting to 6% of the total delivered, but the rejected staves were afterward worked over and the final culling amounted to only 1.38% of the total. The principal defects found, named in the order of their relative frequency, were: Bad ends, rough edges due to dull planer knives or cross grain, pitch pockets, birdseyes and seams, knots, and slanting checks or seams on the ends of staves. In working over the culled staves considerable difficulty was found to lie in cutting off and reslotting the ends properly.

The main difficulty in the metalwork is usually found in the stripping of threads and breaking shoes in the throat between band-head bearings. In the present work an insignificant number of threads were stripped or shoes broken. The material in the shoes was of exceptionally good quality and would stand any amount of hammering and rough handling without breaking or chipping. Shoes usually break in the manner above mentioned when the shoe fits so tightly over the band (usually because of projections on the casting) that hard driving is necessary to force it into place.

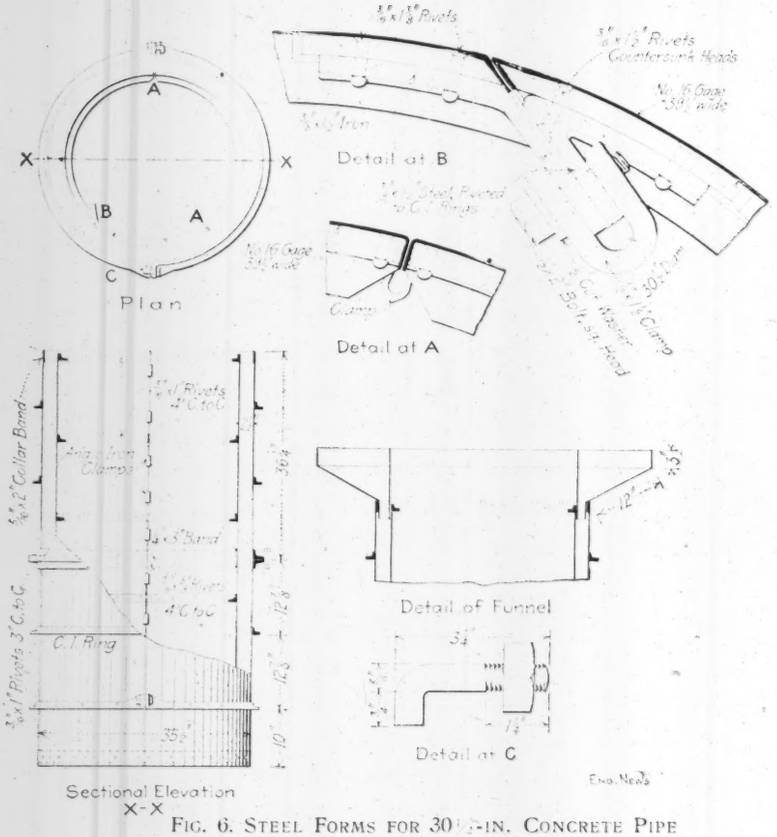


FIG. 6. STEEL FORMS FOR 30½-IN. CONCRETE PIPE

DESIGN OF BANDS AND SHOES—The bands were designed for a working stress of 12,000 lb. per sq.in. The shoe was designed for a maximum tensile stress in the metal of 48,000 lb. per sq.in. (ultimate) and a bearing of 1200 lb. per sq.in. (ultimate) on the stave, both with 60,000 lb. per sq.in. tension in band. This latter can occur only during cinching, at which time the tendency is to dig the heel of the shoe into the wood. (See ENGINEERING NEWS, Vol. 66, page 426, for description of method of designing shoes for wood-stave pipe bands.)

FIG. 7. FORMS FOR 30½-IN. CONCRETE PIPE
(Showing inside form, reinforcement coil and outside form.)

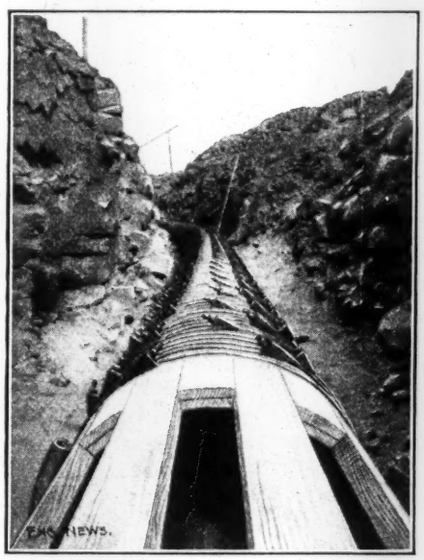
METAL COATING—Before being placed on the pipe the bands and shoes were dipped in a mixture of hot asphalt and after placing, the abraded spots were retouched with an asphalt paint. The specifications called for linseed oil in the coating material, but the contractor objected to its use and held that it was contrary to usual good practice. The writer verified this statement, but for his own information he had some experiments made to determine the effect of linseed oil in the mix on the nature of the coating. These experiments showed that the effect of the linseed oil is to make a coating which will not run at as low temperatures and will not chip at as high temperatures as the pure asphalt coating. In other words, it makes a more flexible coating. Not more than 10% nor less than 7% of linseed oil should be used for best results. The writer would not advocate the use of linseed oil on bands which will always be covered up, but when the pipe is out of the ground and exposed to a large range of temperature, as this pipe is on the bridge, there seems to be no question but that the linseed-oil mixture would be more satisfactory.

INSPECTOR'S OBSERVATIONS—The actions of the materials and pipe during construction were carefully observed by W. A. Rowe, inspector for the Reclamation Service, and the following extracts are taken from his report:

SHRINKAGE, SWELLING, ETC.—The pipe on the south side of the river was subjected to much hot weather and showed shrinkage to a surprising extent. The portion north of the river did not shrink to the same extent because

of its being laid at a later date, because of its being kept moist to some extent by the seepage water from the irrigation running into the pipe trench and because the inlet to the concrete pipe at that end had been plugged, preventing the circulation of the air through the pipe such as obtained in the pipe south of the river. The portion of the pipe between stations 85 and 94 showed the most shrinkage. This stretch on its completion had been thoroughly cinched on Feb. 15 to 17. It was again cinched Mar. 29 to 30 and the bands were taken up about 1 in. on the average. This stretch was again cinched on Apr. 18 and 19 and the bands were taken up an additional ½ in., making a total shrinkage of 1½ in., or more than $\frac{1}{16}$ in. to each stave. The ends of the staves showed more shrinkage than the body, and when this shrinkage was not equal on butting ends there were openings at the seams, even on recinching. Most of these openings swelled shut during the testing of the pipe and those that did not were closed by driving wedges into the stave adjoining the openings. It was suggested that these small ends were due to the planers at the mill, but this I do not believe to be so, because the planers used would not allow the stave end to run off, because the end of the stave was always cut off anyway to square it and finally because I did not observe any of the small ends till after the warm weather in March. The staves were all supposed to have been thoroughly kiln dried. It was strange how much more some of the staves shrank than others. Moreover, I could not observe anything in the staves themselves that would explain this unequal shrinkage.

FIG. 8. LAYING CONCRETE PIPE



FIGS. 9 AND 10. WOOD PIPE IN COURSE OF CONSTRUCTION

I took three pieces of thoroughly sun-dried stave, and after measuring them soaked them for two weeks, observing their dimensions after two days in the water and at the end of the two weeks. The results are as follows:

	Dry	After Soaking 2 days	After Soaking 14 days
Specimen No. 1, cross-grained:			
Radial	1.97	2.00	2.01
Circumferential	5.23	5.27	5.32
Specimen No. 2, diagonal grain:			
Radial	2.00	2.04	2.06
Circumferential	5.29	5.34	5.42
Specimen No. 3, slash grain:			
Radial	2.00	2.04	
Circumferential	5.25	5.36	

*Split up to observe extent of penetration.

From the above it would seem that the full amount of swelling does not obtain after two days of soaking. This was corroborated by observations taken during the testing of the pipe, when it was noticed that many leaks not closed after two days of testing closed subsequently, the seams appearing tight after four or five days of testing. Using the above amount of swell observed in the tests, the swell circumferentially of the 20 staves composing the pipe would amount to 2 in. or 2½ in. Some of this swell was taken up by the crushing of the wood fibers into each other and the remainder by the bedding of the band into the pipe. As it was impossible to pound out kinks or to imbed the band on the lower third of the pipe it is probable that at least half of the swell was taken up by the imbedding of the band.

I could not observe any swelling lengthwise of the staves, although there is doubtless some slight swell but not enough to close butt joints that were open before testing the small amount of $\frac{1}{32}$ in. The slight amount of swell lengthwise of course should be taken advantage of by doing all the wedging of the butt joints before admission of water to the pipe. During the first two days of the test the leaks were mostly all due to shrunk ends. As these swelled shut, the leaks developed in the butt joints, which were then taken up by further wedging.

BUTT JOINTS—During the first month on the job I found it hard to secure good butt joints. There are many factors influencing this work. The stave ends must be sawed square; there must be no marring of these in setting or driving, the line must be good, the grade must be unbroken, there must be no "wind" in placing the staves, and most important of all they must be properly driven and properly cinched after driving. In any case proper driving alone will give joints as good as are possible under the other conditions mentioned. There is no doubt but that the stave ends are frequently slightly out of square because of wobble in the cutoff saw, but it is also true that this is hard to detect and is better than can be done by working them over with a hand saw if they were detected.

The important point in good driving is not to try to drive the stave too hard or to "set" it, in other words; drive the stave only snugly up. If they are struck after they are once up the tendency is to open up both the other joints of the same set as well as the joints of the set back of these if the bands are not tight enough to hold these last. In driving I found it important to get the full effect of heavy blows. To this end the driving bar should be held squarely in line with the stave and the striking done by heavy hitters. It will be found that the joints of the other sets ahead of these being driven are jarred open by the striking. The fewer, heavier strikes in driving, the less will the other joints be opened and the less striking is required then to close

these. The tightness of the bands ahead of the joints is very important. If they are too tight the driving is made hard and the continual jarring serves to open the other joints. On the other hand, if they are too loose the staves will "jump" back and those first driven will be found open on completing the circle. The bands then should be just tight enough to "hold" the drive.

PIPE ALIGNMENT—There are several factors apt to prevent the laying of the pipe in a straight line, viz., roll in the pipe, inequalities in grade, and the difficulty of lining in the center of the pipe. I found it necessary to devise a rod to hang in the pipe with a plumb bob suspended from it to denote the center of the pipe. This bob not only gave a center to sight to in throwing the pipe in line, but also indicated whatever "roll" or "wind" there was in the pipe. In getting out this roll, if the bands are too tight, the pipe will be stiff, in which case the pipe should be rolled beyond the amount necessary to correct it because it will spring back somewhat during the driving. This excess amount of correction is largely a matter of experience, and it is best to try the "wind" after the driving to make sure that the correction was right. A roll in the pipe presents the same appearance in looking along the top of the pipe as a curve in it would even though the bottom stave is exactly in line, the effect being enhanced by the lineup of the shoes.

When the pipe has been rolled it is important in which direction of rotation the driving is done. Looking into the pipe, if it has been rolled clockwise, begin driving at the bottom and drive anticlockwise and vice versa. If the pipe is coming along without needing any rolling, the direction of rotation of the drive should be reversed in driving each successive form.

BLOWOFF—The blowoff at the river is the only special fitting on the pipe. It is designed to discharge the full capacity of the pipe. This would be necessary in case the water had to be shut off from the laterals, as the quantity of 26 c.f.s. could not be carried down the main canal without taxing it excessively. The blowoff valve is attached to the bottom of the pipe directly over the bridge pier 3.

The valve is a standard Crane Co. gate valve. A similar valve, 18 in. in diameter, installed elsewhere on the project and operated in a horizontal position, has

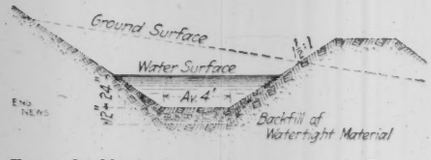


FIG. 13. METHOD OF BLANKETING CANAL IN POROUS GROUND

given considerable trouble on account of breaking of the valve tongue due to the violent vibratory shocks caused by velocities of over 60 ft. per sec. The velocities through the present valve are practically as high, but it was thought that the position of the valve and the conditions of operation were such that the vibrations would not be so violent. This, however, was found not to be the case, and the rattling was tremendous when the gate was opened. There was practically no vibration for a valve opening of less than ⅜ and more than ¾. For any opening between ⅜ and ¾ the intensity of the vibrations seemed to be about the same; that is, they increased very rapidly to a maximum as soon as a ⅜ opening was reached, and did not decrease until the ¾ opening was almost reached, when the decrease was very sudden. An explanation of this phenomenon has apparently been found: After observing the action of the valve and of the discharging water at various stages of gate opening, it was noted that up to the point where the chattering began the water seemed to be running freely from the end of elbow and did not appear to occupy the entire area of the same. At this point, however, the stream, which had a violent rotary motion, seemed to entirely fill the end area of the elbow. This brought forth the idea that when this occurred there was a tendency to form a vacuum and the alternate drawing off and inrush of air, which must have occurred many times per second, caused the tongue to vibrate in the effort to adjust itself to the changing pressures. In explanation of the cessation of vibrations at ¾ opening it was assumed that at this point the back pressure from the elbow was sufficient to cause the valve chamber to be entirely filled with water, thus producing a water cushion for the valve tongue to react against—assuming that such reaction existed. A remedy for the vibrations was produced in the form of a 1-in. hole bored into the side of the elbow just below the valve flange and on the side toward the valve stem, which allowed free access of air to the valve chamber at all times. This showed the vacuum theory at ⅜ opening to be correct and the pressure theory at ¾ opening also, as, at the former there was a strong suction, and when the ¾ opening was reached the water began to spurt out of the hole, showing that the valve chamber was full of water under pressure. The vibrations were greatly reduced by this means, but whether they were entirely eliminated could not be ascertained with certainty on account of the vibrations and loud noise made by the water impinging on the

FIG. 11. FALSEWORK AND TRAVELER FOR BRIDGE ERECTION

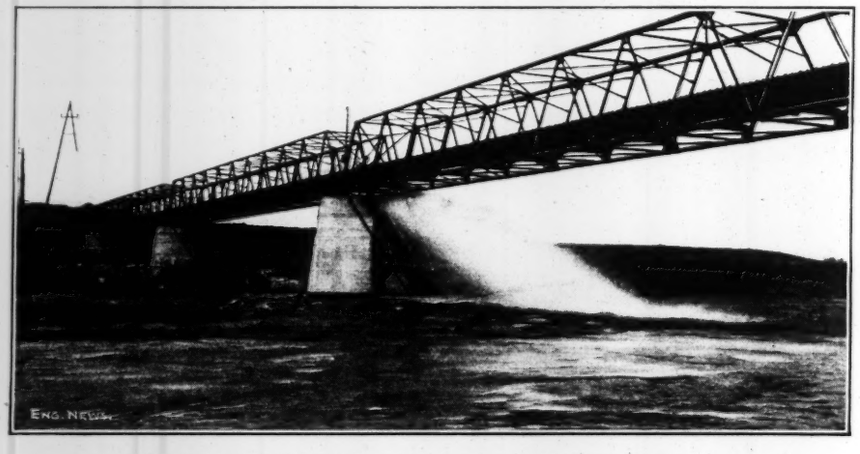


FIG. 12. THE PIPE BRIDGE OVER THE YAKIMA RIVER
(Blowoff operating with valve about half open.)

elbow. There is no question, however, that the conditions of operation are much more favorable for the valve than formerly.

This experience is explained at length with the hope that other engineers may profit by the same, as the writer must confess that he and his associates on this work were for a time baffled for a solution of the difficulty, which had caused considerable annoyance and promised to cause more.

The 18-in. blowoff above mentioned has recently been treated in a similar manner with equally good results. The tongue of this valve had already been twice badly broken by the vibrations. The stem of this valve is vertical and the valve discharges into an 18-in. 45° riveted steel elbow with a 9-ft. radius. Two 1¼-in. taps were made in the top of this elbow just beyond the flange connection to the valve. These openings effectually stopped all vibrations of the tongue, and when the openings were closed or partially closed violent vibrations were again set up. The suction into these openings probably amounts to 8 or 10 lb. per sq.in. The same general phenomena were observed in the action of this valve as in the 12-in. valve previously described.

Bridge

The ways and means of carrying the pipe across the river were a subject of much investigation and discussion. Barring possible accidents and unusual flow conditions in the river, a crossing under the bed would probably have been the cheapest, but some trouble is being had with another pipe which crosses the river under the bed and it was therefore decided not to invite a similar difficulty, but to employ an overhead crossing.

Comparative Estimates—A preliminary comparison of cost and suitability was made between: (1) concrete arches; (2) suspension bridge; (3) wood-stave pipe arches; and (4) long-span plate-girders.

The wood-pipe arches figured out to be the cheapest form of construction, but the uncertainty as to the proper design of the details to take up all possible stresses and the probability of much greater difficulties in the construction caused this scheme to be abandoned. The writer knows of only one bridge built by arching the pipe to carry itself, and this was on such a small scale that experience gained from it was not very valuable in the present instance. The suspension bridge was found to be too expensive and was thrown out of further consideration. The long plate-girders gave a relatively low cost, but were abandoned on account of the desirability of using long spans for which trusses would be cheaper. The concrete arches gave high first cost, but this type of construction seemed so well suited to the situation that the type was retained for further consideration.

The next comparison was made between (1) concrete arches, (2) steel Warren girders and (3) combination wood and steel Howe trusses. In the comparison the depreciation factors were considered, the depreciation factors used being: concrete 1%, steel 4%, wood 10%. This comparison resulted as follows:

Type	First cost	Depr. fund	Total
Concrete arches	$34,874	$103	$34,977
Warren girders	16,505	4,138	20,643
Combination Howe trusses	12,418	8,428	20,846

The concrete arches were rejected on account of their high cost. The Warren girders and combination trusses figured so nearly alike that it was decided to call for alternate bids on these two types. The bids for the superstructure were in each case about 10% less than the estimate.

Adopted Structure—The Warren girder spans were finally adopted and a contract let for their construction for $12,000, including the 50-ft. I-beam span. The spans adopted are: 132, 132, 180, and 50 ft., the last named being a 24-in. I-beam span, whereas the other three are half-through Warren trusses 12 ft. high. The 180-ft. span was chosen so as to have the foundation of its piers above the normal water stage and thus avoid the use of coffer-dams for their construction. The economic construction for the remainder of the bridge would have been I-beam spans of about 50 ft. length, but it was desirable to obstruct the channel as little as possible, so the 132-ft. spans were adopted. The piers were built by force account, to save time on account of the approaching high-water season.

Superstructure—The steelwork is of the simplest kind. The specifications were similar to first-class highway-bridge specifications. No allowance was made for either snow load or impact, as neither of these is likely to occur to any but a negligible extent. The design was based on a uniform load per lineal foot throughout. The probable entire absence of impact and and the fact that the loading is uniform and the fact that the loading is uniform at all times makes the Warren type of girder particularlyadaptable. The main and lateral trusses and sway bracing are made up of angles and plates and the floor system is made up of I-beams. The pipe is carried on wooden ties and stringers resting on the steel I-beams of the bridge floor. Each truss span has one fixed and one roller end and the I-beam span has one sliding end. The entire construction was made without any mishap. The bridge is shown in the photograph, Fig. 12. The falsework for the 180-ft. span is shown in Fig. 11. The deepest portion of the river was spanned by 75-ft. timber trusses resting on rock-filled cribs. These cribs were in about 12-ft. depth of water. They were built on shore and floated into place by means of ropes attached to a highway bridge located about 100 ft. upstream.

Piers—Three of the piers are founded on solid rock, while two are founded on a mixture of clay and gravel somewhat cemented. Some pumping and wet excavation was necessary at one of the latter piers on account of the greater depth necessary to secure good foundation. The concrete used was about a 1:7 mix of cement and river gravel. A large percentage of angular rocks was mixed in the body of the piers, making a relatively cheap construction.

Attention is invited to the front-page view, which shows in the foreground steel flume No. 2. Toward the top of the picture is steel flume No. 1, and the pipe outlet with the bridge just to the left; and on the opposite side of the river the white streak is the road along which the pipe comes down from the main canal.

The excellent views of the work included herein are the work of F. P. Gridley, costkeeper and photographer for the Sunnyside Unit.

Up to the present time the system has been carrying about 22 c.f.s. The pipe promises to carry the full quantity for which it was designed, but the steel flumes will have to be forced to the utmost in order to carry their designed capacity. These flumes are of the patented "Maginnis" type, which have small steel channels projecting on the inside, making the surface very rough. The capacities were calculated by using $n = 0.015$ and allowing 0.4-ft. freeboard. The value of n has been determined by experiment to be higher than this. The manufacturers of the flume material use $n = 0.015$ and make no allowance for freeboard, which is not a safe proceeding.

Distribution System

Laterals—An interesting feature of the main distributing laterals is the method used to prevent seepage where the laterals run through porous material. This material is of two kinds: one a very open gravel and the other a peculiar fine-grained sand-rock, very porous and seamy. Ordinarily a concrete lining would probably have been used in materials like these, but in the present instance an earth "blanket" was used. The method of making this was to excavate the canal prism about a foot deeper than the neat section required and then backfill to the required neat lines with fine earthy material, or top-soil, as indicated in the sketch, Fig. 13. This material was moist when placed and was thoroughly compacted by the tramping of the scraper teams.

This method of treating the previous sections proved to be very effective except where the backfilled material had opportunity to thoroughly dry out before water was turned into the canal. In the

latter case the water succeeded in getting a start through this material at a number of points. These sections were puddled by dumping in more earthy material and tramping it under water. On the whole this method of producing a watertight canal has been found to be very satisfactory and can be recommended for use wherever the required material for the blanket is available.

SUBLATERALS—On the sublateral system, wood construction was used throughoutout. On account of the steep slope of the land from the canal to the river a large number of wood chutes were necessary, and a number of inverted siphons were required to reach isolated tracts. For the latter, machine-banded wood-stave pipes, varying in diameter from 6 in. to 12 in., were used.

The system is built to supply about 2500 acres of irrigable land, of which about 1000 acres were watered during the irrigation season of 1911.

COST DATA

Cost data for the work are given in the tables below.

Cost Data for 30½-in. Concrete Pipe

Total length manufactured	3,288 ft.
Total volume of concrete	219 cu.yd.
Total weight of reinforcing steel	25,000 lb.
Labor and manufacture of pipe:	
Foreman	$5.00 per day
Gas engineer	3.00 per day
Concrete and reinforcing men	2.75 per day
Common laborers	$2.00 and $2.50 per day
Labor laying pipe:	
Foreman	$4.50 per day
Concrete men	$2.60 to $3.00 per day
Common laborers	$2.20 to $2.40 per day
Two-horse team and driver	$4.00 per day

MANUFACTURE AND LAYING:

Concrete:	Total	Per Cu.yd.	Per lin.ft. of pipe
Labor, mixing and placing	$618.52	$2.82	$0.19
Labor, on forms	525.77	2.40	0.16
sprinkling	115.88	0.52	0.04
finishing	102.52	0.45	0.03
Material, cement	728.46	3.32	0.23
sand and gravel	639.36	2.92	0.20
Supplies	81.19	0.39	0.03
Total	$2,812.00	$12.82	$0.88
Collars:			
Labor, mixing and placing	$181.66		$0.06
Material, cement	46.25		0.01
sand and gravel	45.00		0.01
reinforcing	219.00		0.07
Total	$492.00		$0.15
Reinforcement, type C, 1¼-in. spacing:		Per pound	
Labor	$72.56	$0.017	
Material	141.21	0.033	
Total	$215.00	$0.050	$0.56
Reinforcement, type B, 2½-in. spacing:			
Labor	$154.19	$0.017	
Material	293.00	0.033	
Total	$447.00	$0.050	$0.42
Reinforcement, type A, 3½-in. spacing:			
Labor	$226.75	$0.018	
Material	400.00	0.033	
Total	$627.00	$0.051	$0.34
Plant:		Per Cu.yd.	
Depreciation, including forms	$2,658.00	$12.05	$0.80

Cost of Bridge Superstructure

Field labor:

Foreman	$5.00 per day
Carpenters	4.00 per day
Riveters	3.50 per day
Painters	2.50 per day
Common laborers	2.50 per day

	Weight, pounds	Erection	Riveting	Painting 2 coats	Total	Cost per pound
50-ft. span	10,200	$22.25	$15.00	$5.25	$42.50	$0.0042
180-ft.	67,900	135.84	207.50	40.50	383.84	0.0057
132-ft. span	40,840	94.72	154.00	25.45	274.17	0.0067
132-ft. span	40,840	87.47	146.00	25.00	258.47	0.0063
Total labor	159,780	$340.28	$522.50	$96.20	$958.98	$0.0060
Material and shop cost					7031.00	0.0440
Freight and hauling					615.29	0.0039
Falsework material and erection					496.30	0.0031
Paint and brushes					56.75	0.0004
Compressed air					110.00	0.0009
Miscellaneous					70.00	0.0004
Contractors' total cost (not including general expense					9368.32	0.0586

TOTAL COST IN YARD:

Type C pipe	35.70	2.36
Type B pipe	33.60	2.22
Type A pipe	32.30	2.14
Hauling 1½ mi.	2.56	0.17
Laying	7.10	0.47

TOTAL COST IN PLACE:

Type C pipe	$45.36	$3.00
Type B pipe	43.26	2.86
Type A pipe	41.96	2.78

Note: The above figures do not cover general expense.

Cost Data for 31-in. Wood Pipe

Length of pipe	7,500 ft.
Number of ½-in. diameter bands	19,300
Thickness of staves	2 inches
Wood	Douglas fir.
Labor, foreman	$5.50 per day
pipe men	$2.25 to $2.75 per day
common laborers	2.00 per day

BENDING AND DIPPING BANDS AND SHOES:		Two bending tables One dipping vat
Total cost	$291.00	
Cost per band	0.0151	
Cost per pound	0.0020	
Cost per lin.ft. of band	0.0015	
Weight of one shoe	1.04 lb.	
Weight of one band	6.49 lb.	
Total weight	7.53 lb.	
Weight of sphalt per square foot of area covered		0.064 lb.
PLACING STAVES:		
One gang:		
Total cost	$559.00	
Cost per foot of pipe	0.0746	
Greatest run per day	350 ft.	
Average run per day	183 ft.	
Greatest cost per foot	0.110	
Lowest cost per foot	0.043	
PLACING BANDS:		
Total cost	$633.00	
Cost per band	0.033	
Average number placed per 8-hr. shift by two men	151	
Greatest number placed per 8-hr. shift by two men	250	
Greatest cost per band	$0.05	
Lowest cost per band	0.02	
CINCHING BANDS	Two complete cinchings	
Total cost	$444.00	
Cost per band	0.0232	
Average number cinched per 8-hr. shift by 2 men	227	
Greatest number cinched per 8-hr. shift by 2 men	339	
Greatest cost per band	$0.031	
Least cost per band	0.016	
RETOUCHING BANDS AND SHOES:		
Total cost	$50.00	
Cost per band	0.0026	
Cost per lin.ft. of band	0.00027	
Average number retouched per 8-hr. shift by 2 men	2,314	
Number of bands covered by one gallon paint		737
Lin.ft. of bands covered by one gallon paint		5,000
PAINTING PIPE ON BRIDGE, 540 lin.ft., two coats:		
Total cost	$93.00	
Cost per square	1.88	
TESTING AND WEDGING JOINTS:		
(No cost for supplying water):		
Total cost	$90.00	
Cost per lin.ft. of pipe	0.012	
SUMMARY FOR 31-IN. WOOD PIPE:		
Total cost of all items above	$2,160	
Linear feet of pipe built	7,500	
Cost per linear foot		0.288
Cost per inch of inside diameter, per linear foot		0.0093

Note: The above are actual field costs only and do not include contractors' or United States general expense.

Cost Data for Bridge Piers

Labor, foreman	$4.00 per day
carpenters	$3.00 to $4.00 per day
rock men	$2.50 to $2.75 per day
concrete men	$2.50 per day
common laborers	$2.25 per day

	Quantity	Total cost	Cost per cu.yd.
Excavation*	156 cu.yd.	$396.47	$2.54
Concrete	326.6 cu.yd.		
Labor, mixing and placing		$822.92	$2.52
forms		433.05	1.32
Material, cement		730.14	2.24
sand, gravel and rock		914.24	2.80
forms		258.11	0.80
steel		30.10	0.09
Supplies		163.30	0.50
Plant maintenance and depreciation		784.19	2.40
Total		$4,136.05	$12.67

All items are exclusive of general expense.
*Includes 7 cu.yd. earth.
92 cu.yd. compact gravel and clay and boulders.
57 cu.yd. solid rock.

The Aggregate Value of the Mineral production of British Columbia for all years to the end of 1911, according to a bulletin issued by Wm. Fleet Robertson, Provincial Mineralogist, is approximately $397,000,000. The aggregate value of production for 50 years, 1852-1901, was $172,242,000; for ten years, 1902-1911, it was about $224,800,000. Of the value of the mineral production for the whole period of 60 years for which figures are on official record, just about 31%, or nearly one-third, is the production of the last five years.

Proposed Rules for the Measurement of Concrete Construction*

The following divisions are recognized as separate and distinct items in concrete construction:

1. Concrete.
   (a) Monolithic.
   (b) Structural Cast Concrete.
   (b) Cast Concrete Trim and Ornamental Work.
   (d) Sidewalks, Streets and Roadways.
2. Forms.
3. Reinforcement.
4. Surface Finish.

The following general rules shall govern the measurement of the above items, with exceptions where specifically noted:

(a) All work shall be measured net as fixed or placed in the structure.

(b) In no case shall nonexistent material be measured to cover extra labor.

(c) No allowance shall be made for waste, voids, or cutting.

1. CONCRETE

(a) Monolithic Concrete:

The unit of measure for all concrete shall be the cubic foot.

All concrete shall be measured net as placed or poured in the structure or building.

All openings and voids in concrete shall be deducted with the following exceptions:

(a) No deduction shall be made for reinforcement bars, I-beams, bolts, etc., embedded in concrete, except where they have a sectional area of more than 1 sq.ft.

(b) No deduction shall be made for pipes or holes in concrete having a sectional area of less than 1 sq.ft.

(c) No deduction shall be made for chamfered, beveled, or splayed angles to columns, beams, and other work, except where such chamfer, bevel or splay is more than 4 in. wide measured diagonally across the surface.

Each class of concrete having a different proportion of cement, sand or aggregate shall be measured and described separately in accordance with the accessibility and location or purpose of the work.

Concrete in different members of a building or structure shall be measured and described separately according to the amount of labor required in pouring.

Concrete with large stones and rocks embedded in it (cyclopean masonry) shall be measured as one item and described according to the richness of the mixture and the percentage of rock.

In no case shall the measurement of concrete be held to include the forms.

In no case shall an excess measurement of concrete be taken to pay for the cost of forms or extra labor in placing.

Concrete in stairs shall be measured by the cubic foot and shall include surface finish when the mixture is the same throughout.

(b) Structural Cast Concrete:

The term structural cast concrete is taken to include beam and slab construction by the various unit systems now in vogue.

The unit of measurement shall be the cubic foot, and this shall be measured net as provided for monolithic concrete.

The various members shall be measured on the ground before erection.

No measurement shall be taken of forms.

Reinforcement shall be measured separately as provided under reinforcement.

The unit of measure for erection shall be the pound weight of the finished member.

Cast concrete with crushed stone or gravel aggregate shall be assumed to weigh 150 lb. per cu.ft.

(c) Cast Concrete Trim and Ornamental Work:

Cast concrete building trim shall be measured by the cubic foot, but the measurement shall be the smallest cube which will contain the piece measured and not the actual net volume of the piece.

No allowance shall be made for forms.

Miter blocks for cornices, etc., shall be measured separately from straight molded work.

Circular work shall be measured separately from other work.

Vases, seats, pedestals, balusters and other similar items shall be taken by number and description.

No allowance shall be made for reinforcement.

No allowance shall be made for surface finish.

(d) Sidewalks:

Sidewalks shall be measured by the square foot.

The one measurement shall include concrete finish, lining in squares, and cinder or stone foundation.

Curbs and curb and gutter work shall be measured by the lineal foot and separated according to character and size, and shall include foundations, forms, finish, and cost of special tools if any.

In measuring curbs the full height, width or thickness shall be taken.

The measurement of sidewalks shall be taken the full width.

Circular corners and curbs and gutters shall be measured separately by number, stating radius and length measured on the curve.

Vault lights shall be measured by the square foot, the measurement to include glass, forms, steel and finish. Beams under vault lights shall be measured by the lineal foot. In measuring vault lights the measurement shall go at least 4 in. beyond the outside line of the glass in each direction.

2. FORMS

The unit of measure for form work shall be the square foot of actual area of the surface of the concrete in contact with the forms of false work.

Forms shall in every case be measured and described as a separate item and in no case shall the measurement of concrete be taken to include forms.

No deduction shall be made in the measurement of surface of concrete supported by forms because of forms being taken down and reused two or three times in the course of construction.

The unit price for superficial measurement of forms shall be deemed to include the cost of struts, posts, bracing, and bolts, wire ties, oiling and cleaning and repairing forms.

No allowance shall be made for angle fillets or bevels to beams and columns, etc., but curved moldings shall be measured and described separately as hereinafter provided.

No deduction in measurement of forms shall be made for openings having an area of less than 25 sq.ft.

No deduction shall be made in floor forms for heads of columns.

No deduction shall be made in column and girder forms for ends of girders, cross-beams, etc.

No allowance shall be made for pockets in column forms for clearing out rubbish.

The measurement of column forms shall be the sum of the girth of the sides of circumference multiplied by the height from the floor to under side of floor slab above.

The measurement of beam forms shall be the net length between columns multiplied by the sum of the breadth and twice the depth below the slab, except for wall beams and other beams at an edge of floor, which shall have the thickness of the floor slab added to twice the depth.

Wall forms shall be measured for both sides of concrete wall when forms are required for both sides.

Allowance shall be made by number for pockets left for future beams.

Forms to octagonal, hexagonal, and circular columns shall be measured and described separately from forms to square columns.

Caps and bases to columns and other ornamental work shall be measured by number and fully described over all dimensions.

The curved moldings in form work shall be measured by the linear foot.

Forms to circular work shall always be measured separately from forms to straight work.

No measurement or allowance shall be made in slabs or beams for construction joints to stop the day's concreting.

Construction joints or expansion joints to dams and other large masses of concrete shall, however, be measured.

Forms to cornices shall be measured by the lineal foot, and the girth stated. (The term girth shall be taken to mean the total width of all curved and straight surfaces touched by the forms.) Plain forms to back of cornice to be measured separately.

Forms to different parts of structural building shall be measured and described separately according to their position in the building and cost and character of the work involved.

Forms to window sills, copings, and similar work in situ shall be measured by the lineal foot.

Forms to the upper side of sloping slabs such as saw-tooth roofs shall be measured whenever the slope of such slab with the horizontal exceeds an angle of 25°.

Forms to the under side of stairs shall be measured by the superficial foot.

Forms to the front edge of the stairs shall be measured by the lineal foot.

Forms to the ends of steps shall be measured by number of risers.

3. STEEL REINFORCEMENT

The unit of measure of steel reinforcement shall be the pound weight.

Steel rods for reinforcement shall be measured the net weight placed in the building.

The weight shall be calculated on the basis of a square bar 1x1x12 in. weighing 3.4 lb.

No allowance shall be made for rolling margin.

No allowance shall be made for cutting or waste.

*Committee Report before the National Association of Cement Users, Eighth Annual Convention, Kansas City, Mo., Mar. 11-16, 1912.

No allowance shall be made for wire ties, spacers, etc.

In estimating reinforcement the bars shall be measured by the lineal foot as laid. All laps shall be allowed for.

The bars of each different size shall be measured and described separately, as also straight bars, bent bars, stumps, and hooping.

Pipe sleeves, turnbuckles, clamps, threaded ends, nuts, and other forms of mechanical bond shall be measured separately by number and size and allowed for in addition.

Wire cloth, expanded metal, folded fabric and other steel fabrics sold in sheets or rods, shall be measured and described by the square foot. The size of mesh steel in tension and weight per square foot shall be stated. No allowance shall be made for waste, cutting, etc.

Deformed bars shall be measured separately from plain.

4. SURFACE FINISH

The unit of measure for finish of concrete surfaces shall be the square foot. Finish shall always be measured and described separately.

No measurement or allowance shall be made for going over concrete work after removing of forms and patching up voids and stone pockets, removing fins, etc.

Granolithic finish shall be measured by the square foot and shall include all labor and materials for the specified thickness.

Finish laid integral with the slab shall be measured separately from finish laid after slab has set.

No allowance shall be made for protection of finish with sawdust, sand or testing.

Grooved surfaces, gutters, curbs, etc., shall be measured separately from plain granolithic and shall be measured by the square foot to lineal foot as the case may require.

The following shall be measured by the square foot:

Cement wash (state how many coats).
Rubbing with carborundum.
Scrubbing with wire brushes.
Tooling.
Picking.
Plastering, etc.

The Reinforced-Concrete Bridge at Tempe, Ariz.

The recently admitted State of Arizona had under its territorial government an engineering department which comprised a well organized highway division. As a part of the work of this division, in the spring of 1911 it was ordered by the board of control of the territory to build a bridge across the Salt River at Tempe, Maricopa County, about nine miles east of Phoenix, to carry the main line of a north and south territorial highway then under construction. The then territorial engineer, J. B. Girand, proceeded to carry out the instructions and started the design of the bridge a year ago, and since then has begun construction. The bridge, which is described below, from information forwarded us by Mr. Girand, is somewhat out of the ordinary in design.

Salt River at the location of the bridge is normally a small stream only about 40 ft. in width, running through the typical sandy country of southern Arizona. It lies in a wide valley some 1600 ft. from height to height of land, a large portion of which is filled at the time of occasional floods. It was, therefore, necessary to carry the highway on some sort of a structure to a distance of approximately 1600 ft., and after a study of the situation it was decided to build a series of reinforced-concrete arches, each 125 ft. in span, making a total length of 1507 ft. 9 in. The decision to use concrete was reached largely because of the fact that convict labor could be used in the construction, thus reducing the cost of the bridge to superintendence and material.

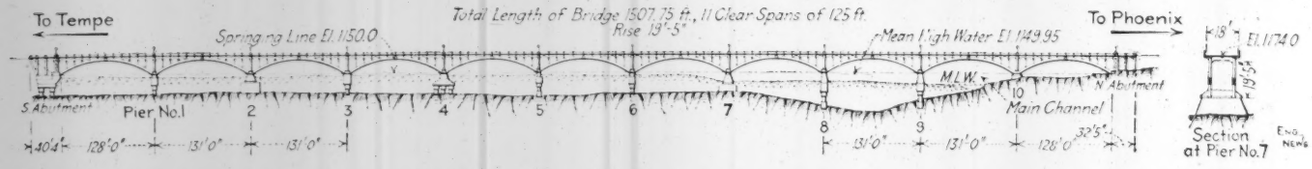


FIG. 1. OUTLINE ELEVATION OF THE TEMPE REINFORCED-CONCRETE BRIDGE ACROSS THE SALT RIVER, NEAR PHOENIX, ARIZ.

On account of the failure of two piers of a large railroad bridge about 500 ft. upstream from the proposed bridge site, it was decided that all piers and abutments of the new bridge should be built on bed rock. Test holes at intervals of 100 ft. along the center line showed that bed rock would be found at an average of 30 ft. below the surface, except in the main channel at the north side of the river bed where the rock had a considerable sag, the greatest depth being 44 ft. below the surface. The general design finally decided upon and the profile of the river bed and the rock bottom is shown in Fig. 1. As shown there, it was decided to make every third pier an abutment pier beginning with Pier 10 and extending to Pier 4. The remaining spans were equally divided by making Pier 2 an abutment pier. The intermediate piers did not require a great width of base for bearing, and as the height of stream line above rock would require an amount of concrete which would have been excessive in cost if carried down to bed rock, it was decided to use two steel cylinders of 6 ft. diameter, driven to rock under each intermediate pier. On account of the depth to rock, this same scheme was used for the south abutment foundation and for Pier 4, except that the number of cylinders was increased in these two.

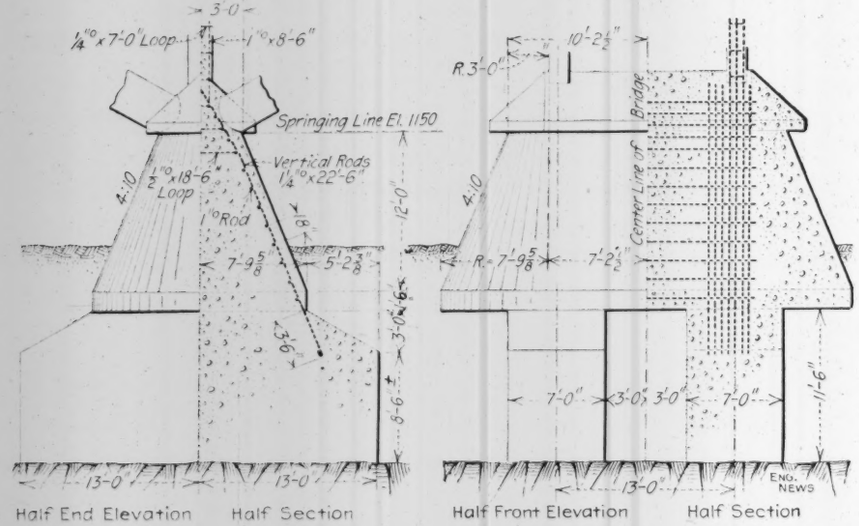


FIG. 2. DETAILS OF PIER 7, TYPICAL OF SOLID-BOTTOM PIERS

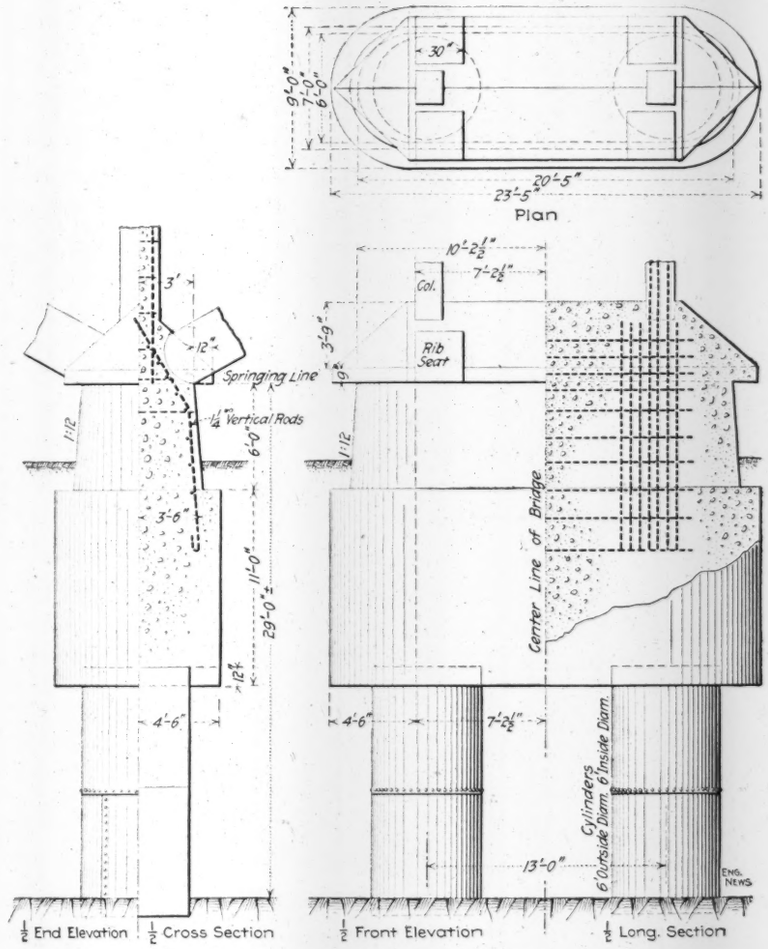


FIG. 3. DETAILS OF PIER 1, TYPICAL OF CAISSON-FOUNDED PIERS

Figs. 2 and 3 show the construction of two typical piers; Fig. 2 representing the abutment pier, No. 7, brought down to bed rock by solid construction, and Fig. 3 showing one of the intermediate piers, No. 1, founded on the steel cylinders. The abutment pier (No. 7) consists of two plinths of concrete 7 ft. wide, transverse to the bridge line, placed 6 ft. apart, and carrying on their top a solid section which is battered up to above the ground level where the skewbacks to the bridge enter. This pier is reinforced, as shown, only against possible contraction or expansion and not to carry any designed load. It will be noted that it is of peculiar design in that the main bearing portion, which is superposed on the two lower plinths, is overhung to a considerable extent.

Pier 1 (Fig. 3) is typical of the intermediate piers founded on the steel cylinders. These piers were constructed by excavating an open cut to the elevation shown at the top of the cylinders and then by sinking the steel cylinders to bed rock by the tubbing method. This tubbing method, as is well known, consists in placing the cylinders on the ground and excavating from them in open, allowing them at the same time to sink to the bed-rock level. When these cylinders reached the bed rock, they were filled with concrete and upon them was then built the solid block which forms the footing to the pier and on this block was placed the battered block shown, which varied in height according to the pier. The same peculiar skewback design was placed on these piers as is shown on the solid abutment piers. In calculating the stability of the piers, the surrounding earth was not taken into account.

The arch proper comprises two three-hinged segmental arch ribs placed 13 ft center to center and carrying the reinforced-concrete slab roadway on spandrel columns. The design of the ribs is shown in Fig. 4. They are, as shown, there, segmental and have a depth of 36 in. at each end and 40 in. at the middle. Their minimum thickness is 17 in. Near the ends they are widened out, having a thickness of 30 in. at the lower end and 24 in. at the crown. These ribs are reinforced with 1⅛-in. round steel rods,

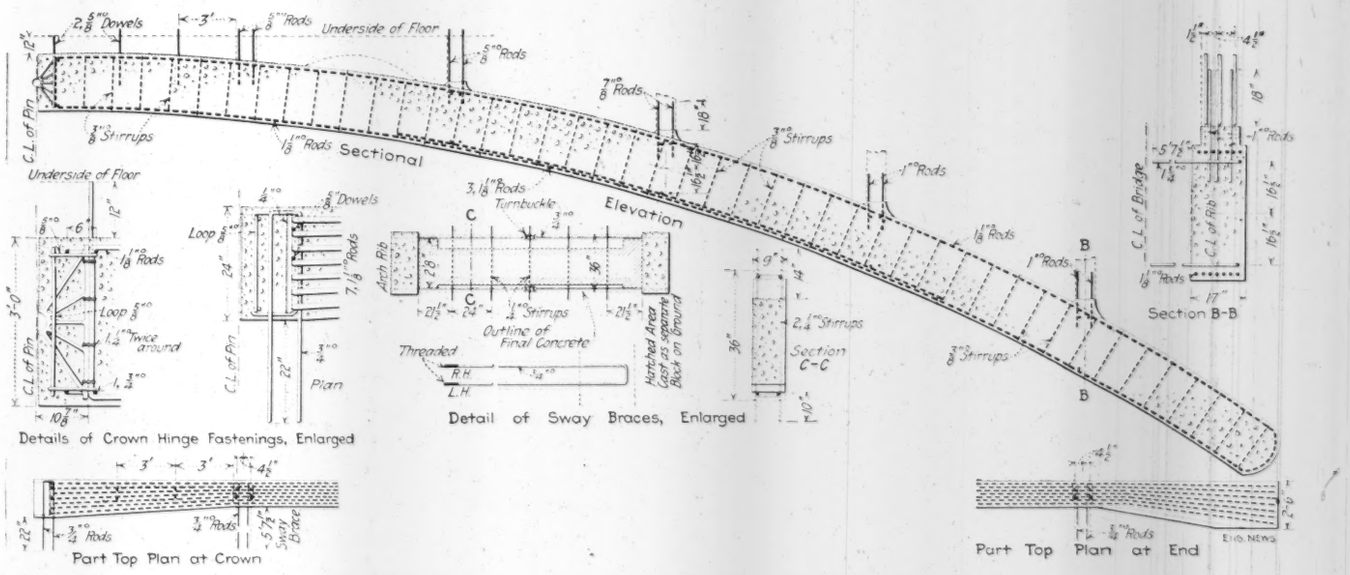


FIG. 4. DETAILS OF ARCH-RIB CONSTRUCTION OF THE TEMPE BRIDGE

longitudinally connected by ⅝-in. round steel stirrups. The hinges at the pier consist merely of a rounded end fitting into a similarly rounded depression in the pier. Galvanized sheet metal is placed in the sockets to separate the concrete of the pier from that of the ribs. At the crown the cast-iron hinge bearing on a 4-in. pin is introduced.

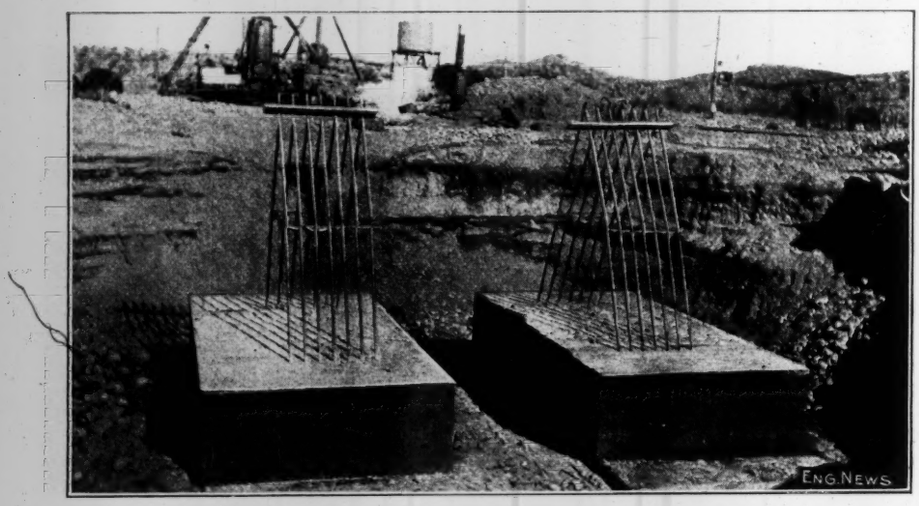


FIG. 5. VIEW OF ONE OF THE SOLID-BOTTOM PIERS

The cross-bracing for the arch rib is somewhat novel, as is shown in the right-hand part of Fig. 4. Here it will be noted that the bracing consists of a solid concrete strut cast in forms on the ground and set in its proper place on the arch ribs. At the locations of these cross-braces steel rods bearing a turnbuckle at the middle are introduced between the two arch ribs during their construction. When the cross-bracing is to be placed, it is lifted into place from the ground and the face of the ribs having been chipped and rich mortar applied it is fitted into place. Then the turnbuckles are tightened until the rods connecting the ribs are as tight as possible and concrete is then placed around the cross-braces, covering both the concrete strut and the turnbuckle rods, leaving the final section a 9x36-in. rectangle.

The floor is carried by 12x12-in. spandrel columns placed about 11 ft. center to center and connected at the top by semicircular spandrel arches longitudinally with the bridge and transversely by girders, which latter carry a beam on the center line of the bridge. Semi-arch brackets cantilevered out from the spandrel columns carry the curb which is designed as a beam and which carries the floor balustrade between the brackets. The balusters are round posts 4 in. in diameter and are cast on the ground.

The floor slab has a thickness of 7 in. at the center line of the bridge and 5 in. at the curb. Expansion joints are provided for this floor at the crown of each arch. The hinges at the crown are masked by a concrete cover-plate. The bridge was designed to carry a 15-ton traction engine plus a live load of 100 lb. per sq.ft. The maximum stresses allowed in the concrete are 700 lb. per sq.in. compression and in the steel 16,000 lb. per sq.in. in tension. As noted above, the entire construction is being carried out under the direction of Mr. Girand, State Engineer; and is being done by convict labor, under supervision of J. C. Ryan, Bridge Engineer. The work of construction was started in the summer of 1911 and is progressing at a fair rate.

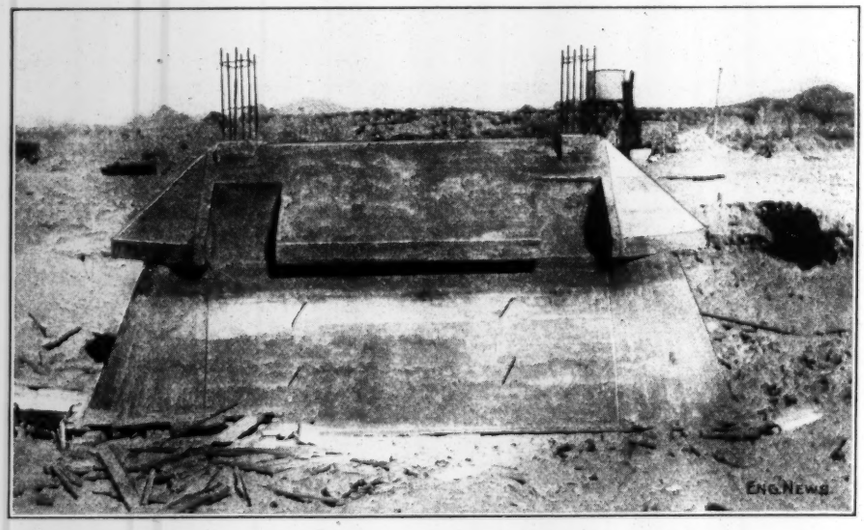


FIG. 6. VIEW OF PIER 7 UNDER CONSTRUCTION

Electric Trunk Railway Operation is actively being planned for in many of the German states. Prussia, Bavaria and Baden have led in this planning, and Saxony is about to consider the subject. The Bavarian and Baden state railways, it is now stated, have adopted as standard the single-phase system, with 15,000 volts trolley-line potential and 16⅔ cycles frequency. This is the same standard as adopted for the Prussian development.

Field Compression Tests of Concrete

BY G. H. BAYLES*

In the spring of 1910 it became the duty of the writer to design and superintend the construction of a reinforced-concrete warehouse in the Borough of Brooklyn, City of New York, for the New York Dock Co. At that time the building regulations of the borough fixed the limit of compressive stress of concrete in flexure at 500 lb. per sq.in. in the outer fiber, with other similarly low unit stresses. From previous experience these stresses seemed to the writer too low, but the borough regulations could not be transgressed, so it was necessary to design the buildings under these specifications. With a view, however, to establishing some authentic strength value of field-made concrete for use in determining the safe allowable unit stress and also to give some criterion of strength by which the time for form removal might be determined, the author decided to carry on during the construction of this and adjacent similar reinforced-concrete buildings a complete series of field tests on concrete cubes made from the concrete as it was placed in the forms for the buildings. Through 15 months, tests were regularly made and proved very useful to the contractor and to the superintending engineer in determining the time for form removal.

On the first contract the tests were put in charge of the two inspectors, both of whom were trained experts in the making and placing of concrete. One superintended the preparation of the concrete and the other placing it in the forms in

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the building, and as the work went on they collaborated in making the cement tests and concrete-cube tests which are the subject of this article. On the second contract, where more concrete was made in a much shorter time, four inspectors were constantly on the work. One gave all his time to testing cement and concrete, another inspected the mixing and proportioning of the concrete and a third the placing of the steel and concrete in the forms. The fourth inspector had general charge of the work.

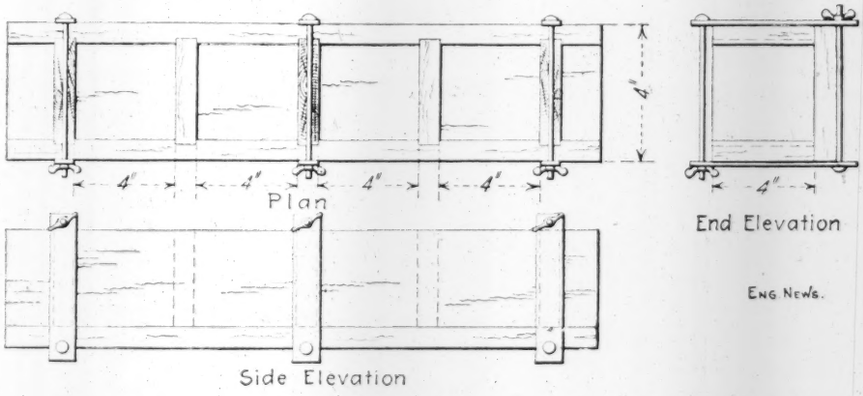

FIG. 1. GANG MOLD FOR 4-IN. CUBES USED IN FIELD COMPRESSION TESTS

In the first place the regulation tests for the cement were made. These included tests for constancy of volume, fineness, time of setting, initial and final, and specific gravity. In addition to the foregoing compression tests of 1:2 mortar were made on 4-in. cubes. In similar work in the future the writer will not undertake to make the tests for initial and final set, because the temperature conditions in field tests are so variable as to render these determinations irregular and of little value. Of all the tests those on the mortar cubes were the most valuable.

For these tests, and the field concrete tests, a gang mold for four cubes was made of lumber by a carpenter on the job. Fig. 1 shows the molds as made. They were not of particularly fine workmanship, but measured up quite accurately in their surface areas. The sand used for these cement tests was taken from that used on the job and washed perfectly clean. Screen tests showed about 21% retained on the 20-mesh sieve, 27% on the 30-mesh sieve and the remainder passing through the 30. These percentages held approximately for all the sand used in the work. The mortar was mixed and placed by hand, using sufficient water to make a medium wet or plastic mortar that was readily puddled. Two cubes were made for each test. One was crushed after 24 hours in the damp closet; the other, when taken from the damp closet, was submerged in water and crushed after six days there, that is seven days in all. The average strength of 173 tests on the first job was 448 lb. per sq.in. in 24 hours and 2075 lb. per sq.in. in 7 days. On the other job a total of 198 tests averaged 570 lb. per sq.in. in 24 hours and 2025 lb. per sq.in. in 7 days. It is sufficient to say of all other tests that they answered all of the requirements prescribed in the standard tests in use in this country and that no car of cement was rejected.

Table III shows the maxima, minima and averages of these laboratory tests on cement mortar, the tests being averaged in blocks of about 50 to show the effect of temperature on the strength.

In addition to these cement tests, strength tests were carried on with 4-in. cubes taken from the concrete as it was placed in the forms. For these tests the gang mold described above was used. A set of four cubes was made every day that concrete was poured, and sometimes twice a day. The concrete was taken from the concrete buggies as it was being poured into the forms and was immediately placed in the cube mold and puddled with a small trowel. There was no excessive puddling, as it was intended to approximate working conditions as nearly as possible. The mold was then placed in the damp closet and kept there for 24 hours, when the form was removed, one cube crushed, and the three others submerged in a pan of water. One of these three was broken after seven days—one day in the damp closet and six in water—and another at the end of 28 days. The additional cube was removed from the water at the same time and laid aside to be crushed at a later date. These latter cubes were crushed on the completion of each job, making the age of the cubes so crushed range from 41 to 336 days.

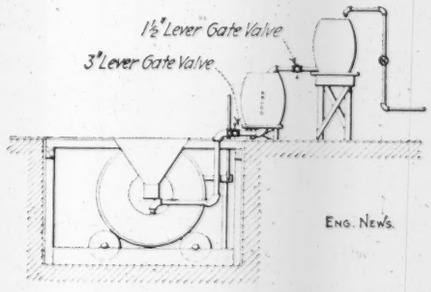

FIG. 2. WATER-MEASURING DEVICE FOR CONCRETE MIXING

The cubes were tested to failure in a hydraulic compression-testing machine of 50-ton capacity, which was kept on the work. On the second job an additional gage, reading only to 10 tons, was put on the machine for use with the newer cubes, whose total strength was below that amount. The regular 60-ton gage was used for all other readings. As the faces between which the cubes were crushed were fixed parallel, three thicknesses of blotting paper were used top and bottom of the cubes to equalize variations of their surfaces. After the first dozen tests were made it was noticed that two sides of the molds were more nearly parallel than the others. By crushing on these sides better and more nearly uniform results were obtained.

On account of some high values which were obtained at the beginning of the work suspicion was directed toward the accuracy of the machine, but comparisons of the cubes by testing on an accurately gaged machine at the testing laboratory of Columbia University showed that the small hydraulic press used on the work was correct within reasonable limits.

The concrete was prepared as a 1:2:4 mixture and each batch consisted of two bags of cement (1.9 cu.ft.), 3.8 cu.ft. of sand and 7.6 cu.ft. of broken stone, the sand and stone being measured approximately in wheelbarrows. The cement was of standard manufacture, one brand being used on the first job, July, 1910, to May, 1911, and a different brand on the remainder. The sand was what is known in New York as "Cow Bay," washed, and the stone a Hudson Palisades trap, commercial ¾-in. size. In mixing the material at first the aggregates were all put into a hopper, the trap opened and the batch pushed into the mixer; then water was dipped with a pail from a barrel and splashed through the hopper into the mixer. The hopper was then closed and while the next batch was being prepared the mixer was revolved twelve times and dumped. This method produced concrete of such varying degrees of consistency that the plan shown in Fig. 2 was suggested to the contractor and immediately installed. By this method the water flows constantly or nearly so from a ¾-in. pipe into the upper barrel; from this barrel a 1½-in. pipe with quick-operating-lever gate valve leads to the lower barrel. To the bottom of the lower barrel a 3-in. pipe, also fitted with quick-opening valve, leads into the mixer under the hopper trap. A number of small holes were bored in the side of the lower barrel. By trial the right amount of water for a batch of concrete was determined and all the holes below the line corresponding to that amount plugged. Only the inspector at the mixer was

allowed to vary this amount. After all the dry material had run into the mixer, which it did more readily since the hopper was always dry, the hopper trap was closed and the 3-in. valve opened. Only a few seconds was required to empty the barrel, when the 3-in. valve was closed, the 1½-in. valve opened and the water allowed to run until it had filled the lower barrel to the holes in the side, which served both to call the attendant's attention and to drain off surplus water. By this method a satisfactory mixture was achieved and the time of mixing reduced by at least a third. Measurements of concrete in place and stone on the scows indicated that the volume of stone used was about 97½% that of the concrete produced.

The tests were carried on from August, 1910, to December, 1911, tests being made nearly every day except during the month of February, 1911, when no work was done on account of inclement weather, and from the completion of the first job in May, 1911, to the beginning of the second in July following. During the latter part of December, 1910, and throughout January, 1911, the sand and water used in making the concrete were heated so that the batch had a temperature of 60° to 65° F. when placed in the forms. Table I, reproduced herewith, shows a typical record for one of the months during this time. The records were kept in total tons on a 4-in. cube, but for convenience of comparison are given here in lb. per sq.in.

Table II shows the resumé of all tests from August, 1910, to December, 1911, the tests for each calendar month being averaged on one line.

While there was considerable variation from the maximum to the minimum, most of the cubes crushed near the average, and reference to the final results indicates that the variation was probably due more to the method of testing than to the quality of the concrete; for while a cube crushed after 24 hours may have been below the average, the cube of the same set broken after 28 days or longer was about as often above the average as below it and *vice versa*. And it seems evident that the actual strength of the concrete and the strength which can be safely counted on in construction is rather above than below the average of the tests made.

Another notable result was the variation due to change of temperature. The laboratory was only heated sufficiently in the daytime for the inspector to do his work and the hydraulic press was protected by covering with a tarpaulin and placing a lamp under the tarpaulin to prevent freezing. During the winter the water in the pans where the cubes were kept froze over several times, so that the temperature surrounding the cubes remained for weeks at a time close to the freezing point, varying only with general changes of weather. The temperature of the damp closet, however, varied more nearly with the daily variations and the results of the 24-hr. tests showed a greater range accordingly. In one instance the concrete had taken so little set at the end of 24 hours that one cube was broken in removing the mold. The crushing load in cold weather was often below 200 lb. per sq.in. and in one case was less than 100 lb. In warm weather, on the other hand, the strength ran correspondingly high, many cubes showing above 750 lb. per sq.in. and with a maximum of 875 lb. Individual tests on the older cubes showed a closer approximation to the monthly averages and these also varied less noticeably from the general average.

These figures are presented in the hope that they may be of some help in solving the problems that are continually arising in the design and erection of concrete structures, and also in the hope of encouraging others to make and report similar or other tests.

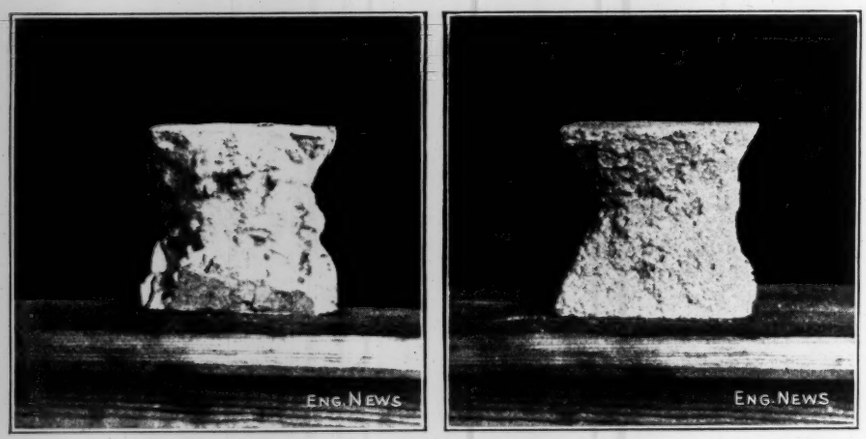

FIG. 3. TYPICAL CUBES AFTER TESTING

Concrete cube on left Mortar cube on right

TABLE I. SHOWING RESULTS OF TESTS FOR ONE MONTH ON 4-IN. CUBES OF FIELD MIXED CONCRETE

Results were recorded in tons on a 4-in. cube, but are given here in lb. per sq.in. for convenience of comparison

Cubes made	Strength in lb. per sq.in. 24 hr.	7 days	28 days	Final strength Age, days	Lb. per sq.in.
9– 6–10	875	1975	3500	316	5000
9– 7–10	438	1694	2500	316	3875
9– 8–10	562	1500	3125	313	4375
9–13–10	562	1375	3125	308	4813
9–14–10	500	1875	3375	307	4625
9–14–10	438	1625	3250	307	5063
9–15–10	750	1875	4375	307	6250
9–15–10	625	2625	3813	306	4813
9–16–10	563	2250	3750	306	5563
9–16–10	600	2188	3750	305	5000
9–17–10	375	1500	3125	304	5250
9–19–10	500	1938	2500	303	5250
9–20–10	688	2250	3500	302	4500
9–20–10	813	2250	3938	301	4500
9–21–10	725	1875	3500	300	4938
9–21–10	562	2125	3750	301	4750
9–22–10	562	2500	3500	294	5875
9–22–10	500	1875	2937	299	4375
9–23–10	750	2250	2688	298	5375
9–23–10	437	2000	3125		
9–24–10	500	2250	3125	299	4688
9–26–10	1000*	1750	2500	297	4688
9–27–10	600	1875	3500	294	4188
9–27–10	875	1875	3125	296	4625
9–28–10	562	1575	2750	294	3750
9–29–10	500	2063	3000	292	4250
9–30–10	562	1875	2875	293	4125
Average	609	1955	3259	302	4789

*30 hours

TABLE II. SHOWING STRENGTH IN COMPRESSION OF 4-IN. CONCRETE CUBES FROM FIELD MIXED MATERIAL

(Each line represents the average of all cubes made in one month.)

Month made	Number of Tests	Strength in lb. per sq.in. 24 hr.	7 days	28 days	Final strength in lb. per sq.in. Age, days	Lb. per sq.in
1910						
Aug.	12	469	1386	2813	330	4339
Sept.	27	609	1955	3259	302	4789
Oct.	16	398	1725	2578	271	4200
Nov.	21	300	1789	3252	246	5103
Dec.	13	256	2015	3933	214	5151
1911						
Jan.	13	233	1565	2943	188	4479
Mar.	18	246	2263	4434	118	6015
Apr.	15	375	2467	4475	85	5588
May	4	656	2031	4125	57	4859
July	10	681	1550	2937	149	4406
			4 days			
Aug.	21	603	1256	2464	106	3995
Sept.	22	507	1205	2477	117	4196
Oct.	21	405	934	2214	88	3950
Nov. 1–14	11	177	538	1938	64	3387
			7 days			
Nov. 15–30	9	193	977	1972	49	3042
Dec.	2	187	844	1690	41	2970

TABLE III. LABORATORY TESTS OF 1:2 CEMENT MORTAR

No. of tests	Cubes made From	To	Strength in lb. per sq.in. 24 hours Min.	Max.	Ave.
50	8–17–10	10– 3–10	375	1250	720
50	10– 3–10	11–21–10	186	1250	585
50	11–21–10	1–25–11	88	437	186
23	1–25–11	3–16–11	38	188	130
173	8–17–10	3–16–11	38	1250	448
50	7–11–11	8–24–11	500	1125	866
49	8–24–11	9–22–11	375	1250	653
50	9–22–11	10–21–11	350	844	495
49	10–21–11	11–25–11	95	475	245
198	7–11–11	11–25–11	95	1250	570

No. of tests	Cubes made From	To	Strength in lb. per sq.in. in 7 days Min.	Max.	Ave.
50	8–17–10	10– 3–10	1675	3500	2426
50	10– 3–10	11–21–10	1675	3250	2473
50	11–21–10	1–25–11	875	2500	1472
23	1–25–11	3–16–11	1125	2000	1489
173	8–17–10	3–16–11	875	3500	2075
50	7–11–11	8–24–11	1563	3250	2294
49	8–24–11	9–22–11	1500	2875	2098
50	9–22–11	10–21–11	1688	2813	2103
49	10–21–11	11–25–11	1375	2375	1865
198	7–11–11	11–25–11	1375	3250	2025

Sanitary Engineering at Harvard University*

By George C. Whipple†

The Graduate School of Applied Science at Harvard University is founded upon the basic principle that engineering, using the word in the larger sense, is one of the learned professions; that the education required of one who enters this profession should be not only scientific and technical, but broad and humanitarian. The engineer of today must not only know the underlying principles of the mechanical sciences and be conversant with the details of his special work, but if he is to become the director of great enterprises he must have the power to think logically and reach conclusions quickly, write clearly and speak forcibly —not to mention such moral qualities as honesty, enthusiasm and that vague something termed personal magnetism. Some of these qualifications are inherent in the individual, some come with experience; but the power to think and speak and write should be a matter of early training, the knowledge of scientific principles should be acquired by the maturing mind and the application of these principles made the last step in the educational process. The instruction in applied science in its utilitarian aspect should be carried only far enough to illustrate general principles and to enable the student to take up some particular line of work intelligently and with such a degree of skill that he can earn a reasonable income during the early years after graduation, when he is getting his real experience in his chosen profession.

It is partly in response to the world's demand for broad-minded engineers, and partly because science itself is becoming so broad and its branches so interwoven, that the applied sciences are being taught more and more as graduate courses in our universities, and that the technical schools are looking forward to longer courses than the usual period of four years. The problem is everywhere the same—how to obtain a proper balance between breadth of study and specialization. That specialization has been somewhat overdone in the past seems to be the verdict of employers; on the other hand, it is equally true that in the attempt to combine various sciences relating to one vocation there has been sometimes too great a dispersion of thought and interest.

Sanitary engineering is one of the fields where there is great danger that the students' energies may be spread out too thin. For this branch of engineering is one that invokes the aid of many sciences. Not only must the sanitary engineer be versed in mathematics and mechanics, but he must have a working knowledge of parts of chemistry, biology, bacteriology, microscopy, meteorology, geology, hygiene, preventive medicine and vital statistics. Unlike other branches of engineering, sanitation is concerned not alone with iron and stone and other inert building materials, but with organic matter and living things. The purification of water and sewage is due largely to biological action, and the knowledge of bacterial processes is scarcely less important to the sanitary engineer than that of the laws governing the flow of water in pipes and the strength of materials. While this is acknowledged, it is also true that, first and foremost, the sanitary engineer must be an *engineer* and the collateral sciences subordinated to the main issue. In arranging the new courses in sanitary engineering at Harvard University this idea has been dominant.

But sanitary science is becoming so important that there is room not only for the engineer but for the sanitary specialist, for the man who devotes his energies to the chemical and biological problems apart from engineering design. Men of this type are now doing useful service, but the need for such men is limited in number when compared with those required to build and operate water-works and sewage-disposal plants, lay out streets and keep them clean, ventilate cars and buildings and otherwise apply the principles of engineering to public hygiene. Many young chemists and bacteriologists have become successful in the operation of engineering works, as, for example, water-filtration plants, but it has been because they have obtained their engineering knowledge in the school of experience; on the other hand, some who have been ambitious in this direction have soon reached the limit of their ability. Such positions are best filled by men of adequate mechanical-engineering training, with a knowledge of chemistry and biology sufficient to enable them to make the necessary routine analyses.

Besides the sanitary engineer and the specialist in sanitation, the world today needs—and the need is very great—a kind of man just beginning to make his appearance—the sanitary executive, or, as he is more often called, the health officer. There are already many so called health officers serving on boards of health. Some of these men are great leaders, well worthy of the honorable positions they hold, but the rank and file of them are ill fitted for their important task. Our public-health machinery was installed when the hygienic wisdom of the town was wrapped up in the family doctor and when the physician was the logical custodian of the public health. With the growth of the science of bacteriology and preventive medicine and the application of engineering all this is changed. The ability to diagnose a case of smallpox and keep a record of deaths is no longer a sufficient qualification for the health officer of even a village, while the growth of our cities is continually demanding that the man in charge of the public health of so many people shall be an expert in his line.

Medical training alone does not fit men for this service. The problem of curing disease is quite different from the problem of preventing disease. The former deals with human beings as individuals; the latter considers them as units of a mass. The prevention of disease involves mathematics; statistics relating to the sick and the dead must be constantly and daily used in order to show what forces of disease are at work, and where the attack is next likely to be made. It involves engineering; for the public must be protected against impure air and infected water, streets must be cleaned and garbage removed. It involves chemistry; for the public must be protected against the sale of adulterated and poisonous foods. It involves bacteriology; for infectious diseases must be diagnosed and antitoxins provided. It involves law; for the health officer must be able not only to discern evils but to eradicate them. But the duties of a health officer should not be entirely repressive and punitive. There is a positive side. His department should be an educational force in the community, constantly instructing the people in the arts of hygiene and in the principles of right living. Many believe that this educational function of the health officer is one of the most important of his duties.

Harvard University aims to provide instruction for sanitary engineers, for those who desire to become specialists in sanitation and for those who desire to become public-health officers. This work is just beginning and the courses first provided and now being given are intended primarily for students of engineering and for those who are candidates for the degree of doctor of public health in the medical school. Later it is planned to broaden the field.

The headquarters of the sanitary-engineering course is in Pierce Hall, Cambridge, where, during the past summer, a laboratory was fully equipped for the analysis of water, sewage, air, filter sand, etc., and for research work in water filtration and sewage purification. A part of the latter work will be carried on in the field at various plants scattered through the state, thus putting the student in contact with actual works in operation. The instructing force includes a professor of sanitary engineering and two instructors in the laboratory, one a specialist in bacteriology, the other, in sanitary chemistry.

*From Bulletin of the Society for the Promotion of Engineering Education, January, 1912.

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Two courses are offered during the present academic year. The first is a general introductory course in sanitary engineering, intended for civil engineers who do not wish to specialize in this direction, for students of the medical school, and for other properly equipped graduate students in the university. This is a lecture and recitation course with little laboratory work. The topics to be covered are water supplies and water purification; rainfall and runoff from watersheds; storage of water; stream pullution; sewerage and sewage disposal; garbage disposal; street cleaning; disposal of trade wastes; plumbing; ventilation; public health; vital statistics; applications of biology and chemistry.

The second course is a specialized course intended primarily for engineers who intend to practice sanitary engineering. It consists of three parts. Part A is a course of laboratory work in the physical, chemical, microscopical and bacteriological analysis of water and sewage, air analysis, analysis of filter sand, etc. It is given during the first term and is in charge of the instructors. Part B is a continuation of Part A and is largely a research course, involving original investigations and field work in subjects connected with water purification, stream pollution, sewage purification, and the disposal of factory wastes. It is given during the second term and is in charge of the professor of sanitary engineering and the instructors. Part C is a course in sanitary design which will be taken up in connection with, and as a supplement to, the course in the theory and design of structures given by Prof. George F. Swain. It is devoted particularly to the design and operation of water-works, filter plants, sewerage systems and sewage-disposal works. It is given during the second term and is in charge of the professor of sanitary engineering and an instructor in civil engineering. Those who wish to devote particular attention to this phase of the subject may omit the laboratory work and devote equivalent time to problems of design. On the other hand, those who wish to devote their attention specially to the laboratory work may omit the course in sanitary design. It is not expected, however, that candidates for the degree of civil engineering will do this.

No special degree is given in sanitary engineering, but the courses above referred to are accepted as a part of the work specified for the degree of Master in Civil Engineering (M. C. E.), this being in accord with the idea advanced at the beginning, that the sanitary engineer should be essentially an engineer.

During the early years, while the number of students is comparatively small, these courses will be thrown open to qualified students not candidates for the master's degree. It is thought that engineers in practice, or those who desire to take up some particular line of research will avail themselves of this opportunity.

The Harvard University Medical School now offers courses leading to the degree of Doctor of Public Health (Dr. P. H.). Although candidates for this degree are recommended to take the medical courses by way of preparation, these are not demanded as prerequisites and arrangements will be made for specialization in sanitary engineering, sanitary chemistry, or sanitary architecture. The degree will be given after four years' work in such branches, or, in the case of medical graduates, after one year's work, provided that the last year's work in the medical school has included certain foundation studies, such as advanced bacteriology, protozoology and preventive medicine. The ability to conduct original research is considered essential for the attainment of this degree. It is the intention of the university to maintain the scholarship involved in acquiring this degree at the highest possible standard, the object being to educate men for leadership in sanitary science. Dr. M. J. Rosenau, Professor of Preventive Medicine and Hygiene, is chairman of the faculty committee on the degree of Doctor of Public Health.

For those who desire to fit themselves as health officers, it is believed that the course in sanitary engineering, supplemented by certain courses in the medical school, the law school and the university, made possible by the free elective system in vogue at Harvard, will furnish an admirable training.

Oil Burning in Boiler Furnaces*

By E. W. Kerr†

In general, it may be said that boilers using oil as fuel have higher efficiency than those using coal. This is due to the greater ease of burning the former without the losses which are more or less unavoidable in coal burning. These losses consist mainly of those due to incomplete combustion and excess air. In coal burning there is also danger of incomplete combustion, due to the fact, even when "excess air" is supplied, that there are still portions of the fuel bed so inaccessible as to not get sufficient oxygen for the formation of CO_2.

In oil burning, there being no thick bed of fuel and with the fuel thoroughly atomized, there is every facility for perfect admixture of all the air admitted and so complete combustion with the least possible "air excess" is secured. It is interesting to note that all of the high records have been accompanied by very low excess air. The following table gives the results of tests showing the performance of a number of oil-burning plants:

Type of Boiler	Calorific value of oil	Water evaporated per pound oil		Boiler efficiency
1. H.R.T..	19,456	15.32	(Ave. of 8 tests)	78.5
2. Water tube..	.....	15.4		79.8
3. Water tube Redondo, Cal.)	18,184	15.15	(Ave. of 8 tests)	80.47
4. Water tube..	17,953	14.42		78.53
5. Water tube..	17,425	14.61		80.97

The above figures, reproduced here from data given in various engineering journals, show performances better than the average and are given to show what may be accomplished by carrying out the proper principles in the design and operation of oil-burning plants. Most of them are averages of a number of tests made by reputable engineers.

The all-important question is: What conditions must be met in order to secure the highest possible efficiency? Among the factors affecting the question may be mentioned the following: (1) Completeness of combustion, (2) quantity of air in excess of that theoretically required, (3) type of burner, (4) form and volume of combustion space, (5) cleanliness of the heating surface.

At a recent meeting of the American Society of Mechanical Engineers, in San Francisco, the subject of oil burning was discussed very fully, ten papers being read upon the subject and some twenty engineers entering into the discussion. It is interesting to note the great stress laid upon the matter of reducing the excess of air to a minimum. In fact, it would seem that the increased efficiency possible in oil burning may be attributed to this, and that most of the factors enumerated above have their importance in the manner in which they affect this one item.

The type of burner is of importance mainly in this matter of the quantity of steam it requires for atomization of the oil and, in general, any burner will atomize the oil if sufficient steam is supplied to it. On the basis of an equivalent evaporation of 15 lb. of water per pound of oil, steam for atomizing equal to 5% of that generated would be equivalent to $15 \times 0.05 = 0.75$ lb. of steam per pound of oil fired, and similarly for other percentages.

In the tests made by the U. S. Naval Liquid Fuel Board in 1904 the steam required for atomizing varied from 1.75% to 10.81% of the total generated. In these tests a large number of different burners was used. Average good practice seems to be in the neighborhood of 3.5% to 4% for atomizing, although the best practice ranges from 1.5% to 3%. At the Redondo plant in California the average steam for atomizing in seven tests was 2.15% of the total generated. It should be said that the steam used for this pur-

*Abstract from Bulletin No. 131, Louisiana State University.

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pose will vary greatly with the same burner.

By reducing the steam required for atomizing there would be a direct saving in the cost of fuel for a sugar factory, grinding 60,000 tons of cane, of approximately $0.01 \times 11{,}500 = 115$ bbl. of oil per season for each 1% of decrease. This calculation is based upon an oil consumption of 8 gal. per ton of cane. According to the figures given above, there is a difference between the best and the worst practice of, say, $10.5 - 1.5 = 9\%$. This would result in a very material difference in the economy of the plant. In addition to the direct consumption of steam for atomizing discussed above, there is an additional loss, which is due to the fact that heat is required to superheat this steam to the temperature of the stack.

So far, the effect of the type of burner on efficiency has been discussed only from the standpoint of its effect upon the amount of steam it requires for atomizing. It is evident that that burner which atomizes the oil and divides it most finely will facilitate most the thorough mixture of the air and the burning oil and that this, in turn, will result in a minimum excess air. In fact, the oil must be vaporized—that is, converted into a gas—before it is burned and, of course, the finer the division accomplished in the atomizing process the more speedy the gasification.

This vaporization may be aided by either or both of two methods, viz.: preheating the oil before it is delivered to the burner or by preheating the air used in combustion. The former is a common practice, especially where the heavier crude oils are used, and during cold weather. By heating the oil its viscosity is reduced and this, in turn, aids in atomization and vaporization. The heating is generally done by means of a heater similar to that used for heating feed water, with exhaust steam from the oil pump.

The writer has been unable to secure trustworthy experimental data upon the economy effected by preheating the oil or the air. Preheating the oil, if the temperature is raised too high, will cause a decomposition of the oil and result in deposits of carbon in the piping and the burner. This will give much trouble. If, however, the heater does not raise the temperature of the oil above the flash point there will be no trouble from this source. Thus the fuel oils, from which the more volatile oils have been removed, may be preheated to higher temperatures than crude oil without trouble from carbon deposits in the supply pipe.

Beaumont oil (fuel oil) used in the tests by the Navy Liquid Fuel Board had a flash point of 216° F. Average crude oil from the same fields has a flash point of 180° F. California oil (fuel), used also in the Navy tests, had a flash point of 311° F. and a residium mixture of California and Texas oils a flash point of 270° F.

The type of burner, however, has little to do with the economy of oil burning compared with the design of the furnace. In the first place, a large volume of furnace is necessary. No matter how well the atomizing process is accomplished by the burner, a certain amount of time is required for gasification and a mixture of the air and the particles of fuel. By enlarging the volume the time of passage through the combustion space is lengthened.

The combustion space may be enlarged by increasing the cross-sectional area or by increasing the length. Theoretically, these two methods fulfill the requirements equally well, provided the volume is the same. In other words, a short furnace with a large cross-sectional area would produce the same effect as a longer furnace with a small cross-sectional area. The velocity of the current would, however, be greater in the long narrow furnace, and more draft would be required with this arrangement. In the case of horizontal tubular boilers, where the under side of the boiler shell constitutes one wall of the combustion space, the long narrow arrangement will bring a larger proportion of the gases in contact with water-cooled heating surface prior to combustion, a thing always to be avoided when possible.

On the other hand, the entire combustion space is more likely to be effective in the narrow furnace—that is, there is less likely to be short-circuiting of the gases across portions of the furnace. It may be said, however, that the latest practice tends to approve the short and wide arrangement.

With very wide furnaces, in some cases, baffle walls and arches have been built in for the purpose of compelling a thorough filling of the entire combustion space, the former by scattering the flame and the latter by holding the flame in the front part of the setting. Present practice seems, however, not to favor these adjuncts, the burner being depended upon, by its fan or cone-shaped flame, to diffuse the gases through the entire space. It is important in designing an oil furnace to arrange so that the flame is well distributed over the heating surface and that no part of the latter is subjected to intense local jets of flame, as it is very easy to injure the metal materially in this manner. This, in fact, is one of the harmful effects which result from the baffles and walls mentioned above.

One of the most effective and satisfactory arrangements is to have the floor of the furnace gradually slope upward from the front of the furnace to the bridge wall, in some cases paved and smooth and in other cases made of brickbats piled loose. Either of these constructions throws the flame to the heating surface and at the same time at such a small angle as to insure against local impingement of flame.

This arrangement aids also in fulfilling another requirement for efficient oil burning, viz.: that the combustion take place in a space surrounded with firebrick. This brick becomes incandescent and the heat radiated from it aids materially in the gasification of the fuel in the quickest possible manner.

Having a properly designed furnace will not secure the highest efficiency unless the air supply to it is carefully regulated. In fact, it would seem that this is of most importance. The front of the furnace—in fact, the whole setting—should be air tight with air openings so arranged as to be easily regulated. If the air is admitted through the draft doors their position should be carefully adjusted so as not to give too much or too little air, the greatest cause of loss being in the former.

Many—in fact, most—of the smoke stacks used with oil burners in the sugar factories were formerly used for coal burning, the height of the stack being made to suit that fuel. The result is higher stacks and greater draft than is necessary for good economy. One expert in oil burning cites a case where the stacks in a large plant were blown down, only 35 ft. being left, and yet the load was easily carried.

One authority states that a draft of 0.1 in. of water in the last pass of a water-tube boiler is sufficient for the best economy, and that with 0.5 in. draft a loss of at least 10% in fuel may easily result.

To summarize, there are three main essentials for the best results in oil burning, viz.: (1) a furnace with proper design as regards volume of combustion space and distribution of gases on the heating surface; (2) complete control of the air supply, and (3) thorough atomization and gasification of the fuel as early in the process as possible.

An Interesting Piece of River Revetment work on the Missouri River was recently completed by De Witt & Shobe, Contractors, of Glasgow, Mo., for the Missouri Pacific Ry. The work consisted of 2000 ft. of revetment on the river bank in front of the railway station at Lupus, Mo., where erosion was threatening a side track, the main line and the station building itself. The work had to be done at once, in midwinter, when the river was covered with ice. A willow mattress 64 ft. wide and 2000 ft. long was woven on the ice along the bank; as the weaving progressed the work of ballasting the mat with stone was also carried on, and the ice cut along the outstream edge, allowing ice, mat and ballast to sink together to the river bed, directly behind the weavers, thus obviating the chance of the mat being carried away by the breaking up of the ice. The number of days actually employed in weaving was 16, and the number of weavers per day averaged 4½. The bank was graded to a 1 or 2 slope and paved with rock.

Cleveland Intercepting Sewer System

By J. M. Estep*

Intercepting sewers are being built at Cleveland, Ohio, to divert the sewage from the rivers and their tributaries and from the lake front, and to convey the sewage to a point of discharge some eight miles distant from the city water-works intake. The history of the project is outlined and the leading features of the work described. Part of the main intercepter was constructed in open cut and part of it in tunnel. Some of the sewer is of reinforced concrete, lined with brick, and part of it of brick alone. The lake outlet is of riveted steel.

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ENGINEERING NEWS, in its issue of Feb. 20, 1896, contained an abstract of a report by Rudolph Hering, Geo. H. Benzenberg and Desmond FitzGerald, expert engineers appointed by the city of Cleveland to act as a commission to examine and report upon plans for the extension of the water system, disposal of sewage and purification of the river. The present article will show what has been done and what remains to be done to complete the intercepting sewer system in general accordance with the suggestions and recommendations of the commission.

The city of Cleveland is ideally located for drainage by a gravity system of sewers and for sewage disposal by dilution, since the Cuyahoga River and its tributaries on the one hand and Lake Erie on the other afford convenient outlets for all the sewers of the city.

The greatest amount and the most serious source of pollution, as far as the water supply of the city is concerned, comes from the Cuyahoga River, which now receives 52% of the entire sanitary or dry-weather flow of the city. On account of the very low velocity of the river, the bottom of the latter is covered with a heavy sewage deposit, much of which, at the time of the spring freshets, is washed out into the lake, where, at times, it is possible to contaminate the water supply to some extent.

The intercepting sewer system was designed for the purpose of intercepting the dry-weather flow of all sewers emptying into the river, its tributaries and the lake, and conveying this flow to an outlet located on the shore of Lake Erie at a safe distance to the east of the new water intake, to avoid as far as possible any danger of contaminating the water supply by discharging the raw sewage into the lake.

The area drained by the intercepting sewer system comprises 38,549 acres, of which 16,467 acres lie outside of the present city limits and 22,082 acres inside of the city limits, 412 acres of which constitute the congested district. The system is designed to meet the requirements of a population of one million inhabitants upon a basis of 54 cu.ft. per capita per day, of which 27 cu.ft. is sewage and 27 cu.ft. storm water. A density of population of 20 inhabitants per acre was assumed for the territory lying outside of the city limits, 30 per acre inside and 320 per acre in the congested district.

The outlet of the intercepting sewer (Fig. 1) is in Lake Erie, one-half mile from the shore, and about eight miles easterly from the new water intake. The sewer extends westerly, in a general direction, approximately parallel with the lake front, and at an average distance of about 1000 ft. therefrom, from the outlet to the westerly city limits. It intercepts the sanitary flow of all the sewers emptying into the lake, and, by the construction of branch interceptors, the sewage now being discharged into the river and its tributaries will also be diverted to the intercepting sewer.

The intercepting sewer system, as planned, consists of a high- and a low-level interceptor. The high-level interceptor conveys by gravity to the outlet the sanitary flow of all the sewers intercepted. The low-level system will be constructed in the low lands of the river valley and will receive the sanitary flow of all the sewers that cannot be drained by gravity into the high-level interceptor. The low-level system comprises an area of 3712 acres and is based on a flow of 27 cu.ft. per capita per day without an equal flush of storm water, as in the high-level system. The sewage in the low-level system will be conveyed by gravity to convenient locations, where it will be pumped into the high-level interceptor. A separate system of storm sewers will have to be constructed in connection with the low-level system.

The city sewers are constructed principally on the combined system, the only separate sewers being such as have been acquired by the annexation of adjoining municipalities, and they form only a small part of the sewer system of the city.

All flow in excess of 54 cu.ft. per capita per day in the main sewers intercepted, is diverted from the interceptor and discharged into the lake, river and its tributaries, and the sill of the overflows are adjusted at the proper elevations for this purpose.

The main interceptor is constructed on a grade of 2 ft. per mile. At the outlet, the sewer is 13½ ft. in diameter, and has a capacity of about 640 cu.ft. per sec. The sewage from the interceptor flows into a basin constructed of concrete and steel (Figs. 2 and 3). This basin is about 60 ft. wide, 100 ft. long and 18 ft. deep. At the present time, no treatment, other than rough screening, is attempted. From this basin the sewage is conveyed into the lake, a distance of 2650 ft., by means of a submerged steel pipe 5¼ ft. in diameter.

The basin is so arranged that the flow from the sewer can be discharged through a bypass sewer directly into the lake or outlet pipe as circumstances may require. The inlet to the basin is provided with two screens for the purpose of preventing the coarser matter from entering the basin. Another screen is placed at the opening to the outlet well. This screen prevents some of the matter that may pass the other screens from entering this outlet pipe. A sump is provided at the lower end of the basin from which a pipe leads under the floor to the outside of the basin, where an operating valve is placed by means of which the contents of the basin can be discharged into the lake.

The deposits taking place in the basin are principally formed from sand coming from the streets during the first flush of storm water before overflowing. These deposits are removed at intervals by the use of an electric hoist, which travels across the front of the basin over the part where the deepest deposits occur. The basin is covered by a steel-frame structure (Fig. 3) of very neat appearance, having a ventilating tower in the center at one end for removing the odors arising from the basin. Before the basin was covered, the odors were a source of considerable annoyance to the inhabitants in the vicinity.

Forty per cent. of the sanitary flow of the city is being delivered at the outlet. The submerged outlet pipe before mentioned is not large enough to care for the entire sanitary flow of the system, but it is ample for the present service. Eventually, one or more pipes will have to be laid and carried out as far, or perhaps farther, than the present one.

The outlet pipe is made of riveted steel boiler plate, dipped in a preservative coating. The pipe (Fig. 4) was made up in 50-ft. lengths, with a heavy angle-iron flange riveted on each end. These lengths were delivered at the dock at the foot of East Ninth St., at Lake Erie, and there assembled into lengths of 150 ft., bulkheaded at the ends and towed a distance of about eight miles to the trench at the outlet. Openings were then made in the

bulkheads and the pipe was allowed to fill slowly and gradually settled to its proper place in the trench, where the diver connected the lengths by means of a special submarine joint, shown in Fig. 4. The outlet end of the pipe is protected by a caisson surrounded by riprap stone.

Work was begun on the outlet section of the main interceptor in 1912. The sewer arch was of monolithic construction, of reinforced concrete, the section below the spring line being squared out at the bottom and constructed of plain concrete with an invert lining of shale brick. About 14,600 ft. of this style of construction was made in open cut, which for most of the way was located on the right-of-way of the Lake Shore & Michigan Ry., or on adjacent private property parallel with the railway right-of-way. The average depth of the sewer was about 40 ft., the material encountered being sand, quicksand and clay. Where the sewer was constructed on the railway company's right-of-way, the company required the city to use 9-in. Wakefield sheet piling, instead of the 3-in. sheeting used at other places. This style of sheeting added about $20 per lineal foot to the cost of the sewer.

In passing a one-story brick building used as a machine shop, some damage was done to the building, which was located very close to the sewer trench. A little further along on this contract it was necessary to pass a three-story brick building of considerable size. It was decided to tunnel the remaining portion of the contract. A subsidiary agreement was accordingly entered into whereby the contractor agreed to construct the remaining portion of his contract, about 1100 ft., in tunnel at the average price per lineal foot that the work was costing in open cut, or $80.04.

The inside diameter of the tunnel portion was 13½ ft., and the outside diameter was 16½ ft. The tunnel was lined with four rings of shale brick, laid in portland-cement mortar. An hydraulic shield was used which was operated by twelve hydraulic jacks. The plant equipment included air compressors, hydraulic pump, dynamo and other machinery necessary for the successful operation of the work. The tunnel was lighted with incandescent lamps; about 7 lb. of air pressure was maintained, which ordinarily was sufficient to keep the tunnel dry and the face in good working condition for the miners.

The excavation was principally through plastic clay, which was removed by us-

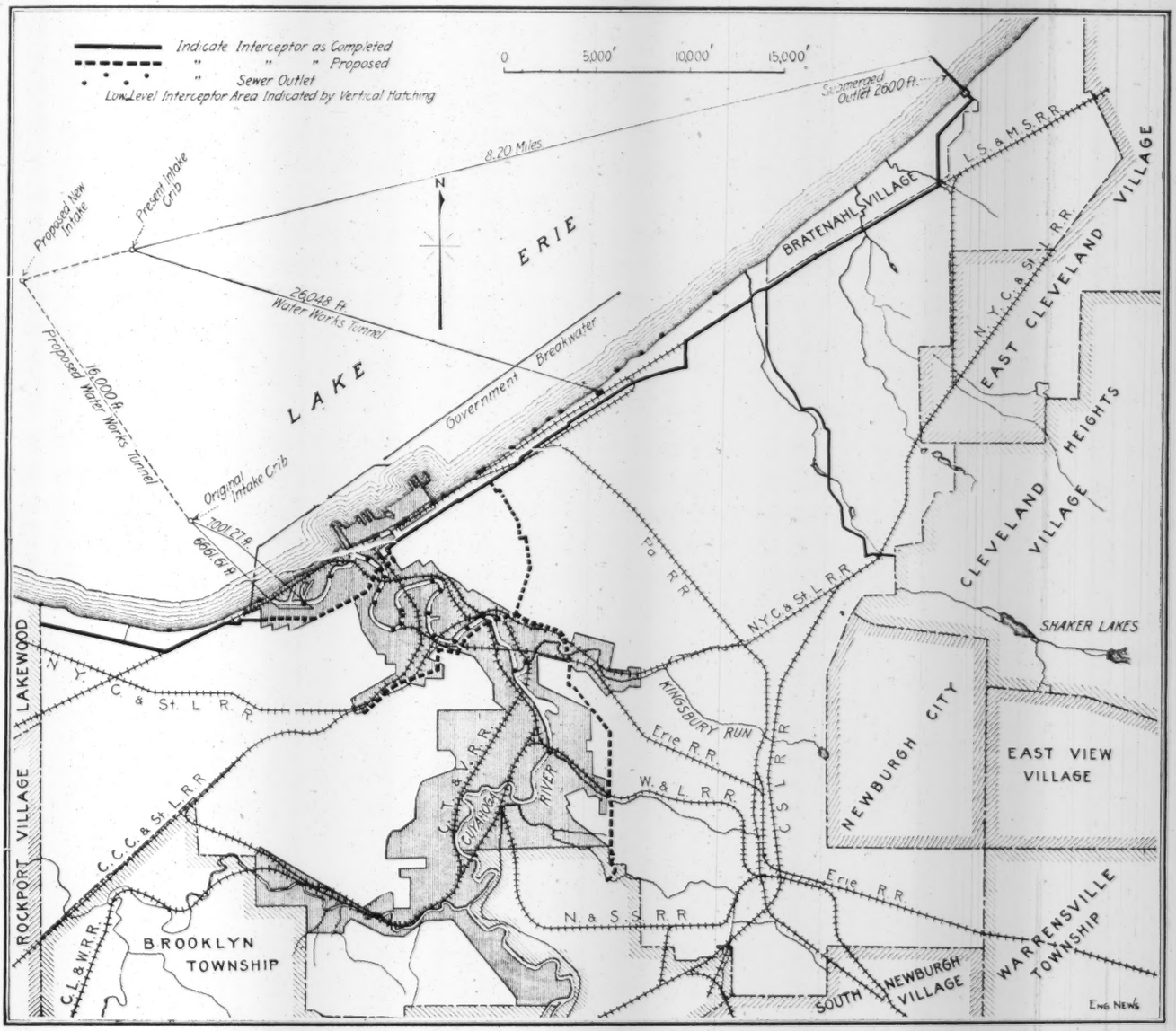


FIG. 1. THE INTERCEPTING SEWER SYSTEM OF CLEVELAND, OHIO, IN ITS RELATION TO THE RIVERS, THE LAKE AND THE CITY WATER-WORKS INTAKES

ing large draw knives, usually three miners to a knife. The jacks pressed against the outer rings of masonry and no damage was done to the masonry except at the direct point of application of the jacks, and this small amount of masonry was relaid each day. There were 8 cu.yd. of excavation per lin.ft., and 2.62 cu.yd. of brick masonry per lin.ft. On this work an average rate of 6 ft. per day was maintained. The work progressed night and day, regardless of the weather. The brick building above referred to was passed without the slightest injury resulting to it on account of the tunnel construction.

On account of the success of this method of construction it was decided to build the adjoining section in tunnel instead of open cut, as the original contract called for. This sewer was of the same size and style of construction as the other section, but the average price per lineal foot was $71. A court decision was rendered, in which it was stated that the cost of the work could not exceed the amount appropriated therefor. Accordingly, the contractor performed the work for $59.75 per lin.ft., thus keeping within the appropriation.

On this contract, 50% more progress was made, by the same method, than was made on the adjoining section. A close record on this work indicated that the contractor made a handsome profit, even at his reduced price, and set a new figure for tunnel work in this city. This was in 1904, since which time all of the main intercepting-sewer work has been done in tunnel, making a total to date of 24,500 ft. so constructed.

A modification of the foregoing method was adopted in the construction of the last 12,000 ft. of tunnel, by substituting a 6-in. wood lining for the outer ring of brick, made up of segments or cants of convenient size for handling (see Fig. 5). The pressure of the jacks was taken by the cants instead of the brick masonry, as in the first construction. Inside of the wood lining three rings of shale brick were laid in portland-cement mortar. This method was used on sizes of 12 and 12¼ ft. in diameter. A portion of the sewer was built in a street lined with manufacturing plants and part of it was constructed through private right-of-ways passing under small residences and near structures of considerable size. No serious damage was done to any structure. In a few instances the contractor had to shore up some buildings and make a few repairs to walls and foundations, and, in all cases but one, these matters have been satisfactorily adjusted. The hydraulic shield, air pressure, etc., were used on all of the work.

The use of the wooden cants proved to be a cheaper method of construction than the old method of an all-brick section. The excavation was followed up closely with the wooden lining. The cants were toe-nailed in place and the arch blocks wedged up close to the excavation. More progress was made in this way than by the old method, as the excavation and lining could be carried on regardless of the masonry.

The last 6800 ft. of 12¼-ft. size was built by this method at an average cost of $35 per lin.ft., not including manholes. This 6800 ft. was divided into two contracts, which were performed by one contractor. The work was prosecuted from three headings. Two right-angle curves were made. No extraordinary refinements were used in giving lines and grades. The instrument man simply used great care in transferring his line and grade to the bottom of the shaft, from which short base lines the work was carried on in both directions from the shaft. No intermediate line holes were made at any part on the work. A shield was started from the extreme westerly end of the work and shoved easterly 1900 ft., where it met to perfect line and grade the shield that traveled 2500 ft. westerly around two right-angle curves. The shields were left in place and the shells filled with cement. The shields were so constructed as to allow the inner ring of masonry to be laid inside of the shield in conformity with the rest of the work.

The main interceptor is completed on the east side of the river from West Ninth St. to the outlet in Lake Erie., a distance of approximately eight miles,

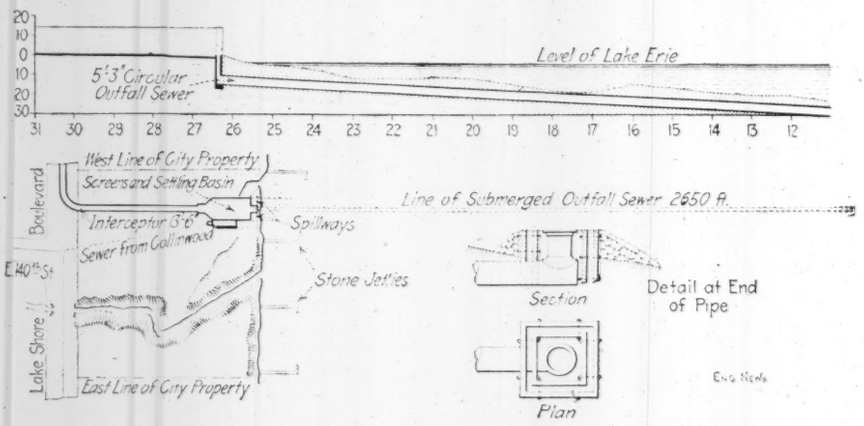


FIG. 2. GENERAL LAYOUT OF TERMINAL SEWAGE BASIN AND THE LAKE OUTLET SEWER, CLEVELAND, OHIO

the sizes varying from 8¼ to 13½ ft. in diameter. On the west side of the river it is completed from the westerly city limits to West Fifty-eighth St., a distance of 2.4 miles. This portion of the sewer is of the combined system, provided with storm overflows.

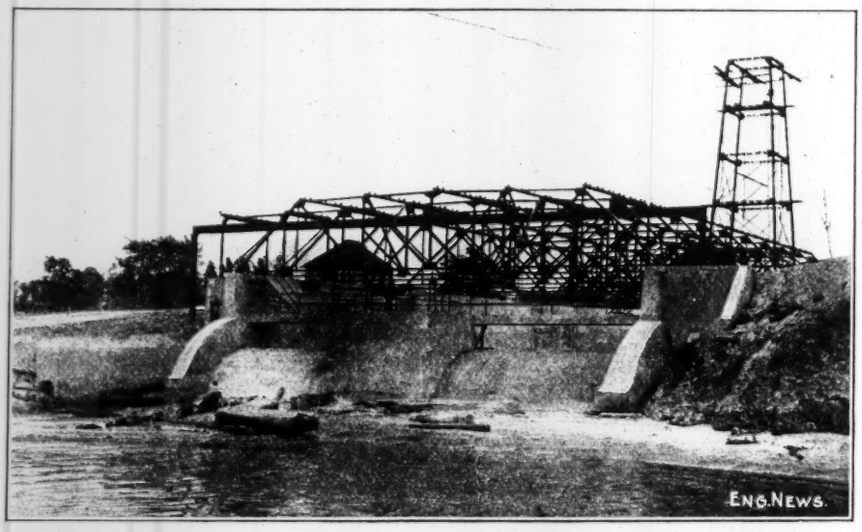


FIG. 3. STEEL COVERING FOR TERMINAL BASIN, CLEVELAND INTERCEPTING SEWER

The part of the main interceptor remaining to be built lies between West Fifty-eighth and West Ninth St. This section will necessitate the construction of an inverted-siphon crossing under the river. This part of the work will not be done immediately, as the construction of some of the branch interceptors is of more immediate necessity in order to remove the sewage now polluting some

of the tributaries of the river. Several branch interceptors have been constructed, and one is now under construction, which will remove considerable of the sewage from one of the branches of

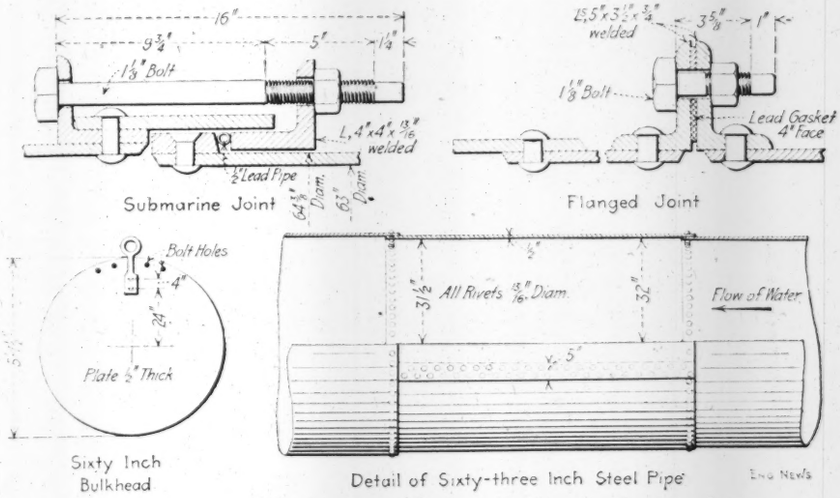


FIG. 4. DETAILS OF RIVETED STEEL OUTLET SEWER AND SPECIAL JOINT, CLEVELAND, OHIO

Dugway Brook, a stream passing through a very good residential section of the city. The flow in this stream is very low during the dry summer months, so that the pollution of the stream by the sewers is very much in evidence, causing numerous complaints to be filed with the city on that account. Plans, however, are being prepared for sewering this stream.

The total length of the high-level system, including the branches which will have to be built, is about 30 miles, half of which is completed. No work has been done on the low-level system.

The cost of the intercepting sewer system to date is approximately $2,500,000, and $1,750,000 will be required to complete the entire system.

The city is authorized to sell intercepting-sewer bonds to the amount of $1,000,000. Of the amount realized $300,000 will be used for constructing what is known as the south-branch interceptor, extending from the main interceptor at East Twentieth St., southerly 8300 ft. to Broadway. This section of the sewer will be 9 ft. in diameter, and will be constructed in streets thickly built up with business blocks, churches, apartment houses and the large Y. M. C. A. building now in course of construction. The depth of the sewer will be about 65 ft. to the top of the arch, where the sewer passes the largest and most important structures. The borings indicate plastic clay at the sewer depth. The sewer will be constructed in tunnel, probably with an outer rim of wood lined with shale-brick masonry.

The new water intake is located about eight miles westerly from the intercepting sewer outlet. The experiments conducted by the city for the expert commission relative to the lake currents caused by winds indicated that the prevailing winds were such that it was thought no contamination could reach the water intake from the sewer outlet. In calm weather the sewage can be readily located coming from the submerged outlet pipe, and it is confined to a surface area about 100 ft. in diameter, outside of which the water has its natural color and appearance. It is not thought that any of the sewage from this source reaches the water intake, but that such evidence of sewage contamination as does exist at times in all probability comes from the river and such other sources as have not yet been connected with the interceptor.

FIG. 5. VIEW IN 12¼-FT. INTERCEPTING SEWER, CLEVELAND, OHIO, SHOWING SHIELD, WOODEN CANTS AND BRICK LINING

The subject of sewage treatment is now being taken up by the city. R. W. Pratt, formerly chief engineer of the Ohio State Board of Health, has been retained by the city to report upon and recommend some plan of sewage treatment. A summary of Mr. Pratt's report to the chief engineer of the Cleveland Department of Public Service appeared in ENGINEERING NEWS of Feb. 8, 1912. It will probably be several months yet before a final report can be made upon the subject. It is recommended that a series of tests and experiments be conducted covering a period of about one year, in order to determine the most feasible method for the treatment of the sewage.

It is quite probable that a testing laboratory will be installed at the main outfall, together with experimental tanks and filters, for the purpose of determining just what method of treatment is best adapted to local conditions.

Should the sewage of a large portion of the southerly part of the city be treated up the Cuyahoga River Valley, at some location outside of the city limits, the south branch interceptor, above mentioned, will not be constructed, but instead, an interceptor flowing in the opposite direction will have to be constructed to convey the sewage to the disposal plant. This will reduce the amount to be treated at the disposal works to be located at the main outfall.

A third treating plant may be located at the outfall of the West 58th St. sewer on the shore of Lake Erie. This sewer delivers about 8% of the dry-weather flow of the city at this point. At the present time it cannot be stated just what degree of purification of the sewage will be required.

Should the city decide not to purify the water supply by means of filtration, then a higher degree of purification of the sewage effluent than would otherwise be necessary will undoubtedly be required.

Balanced-Compound Locomotives

The traffic development on the A., T. &. S. F. Ry. has necessitated the introduction of a larger and more powerful engine for high-speed passenger service in districts where the grades are severe. The new type of engine designed is six coupled, of the 4:6:2 type, with four cylinders, a crank axle, superheater and Jacobs-Shupert firebox. The design combines several special features with a general adoption of parts and patterns already in use. The article is prepared from information furnished by the railway, covering both the general design and the special features.

The Atchison, Topeka & Santa Fé Ry. has been notable for some years for its activity in the development and introduction of special designs of locomotives adapted for the handling of heavy train loads. Prominent among these engines have been the 2:10:2 four-cylinder tandem-compounds and several classes of Mallet engines, some of which have been described in our issues of Apr. 20 and May 4, 1911. While this line of development has been mainly in regard to freight traffic, the equipment for passenger traffic has not been overlooked. Four-cylinder balanced-compounds have been introduced for high-speed trains, and a very exceptional type of locomotive is a Mallet 2:4:6:2 engine for handling fast and heavy trains on a division having severe grades and curvature.

The latest development in passenger equipment on this road is the design of a four-cylinder balanced-compound locomotive of the 4:6:2 class for service in districts where heavy grades occur. This new design includes a number of interesting features, and for particulars of these we are indebted to the motive-power department of the road. One of the new engines is shown in Fig. 1, and 28 of these have been built already by the Baldwin Locomotive Works. The main requirement was for greater power at high speed than was available in engines of the 4:4:2 class, and a six-coupled engine was seen to be necessary. Satisfactory service has been rendered by balanced-compounds of the 4:4:2, 4:6:2 and 2:6:2 classes, and these considerations led to the adoption of a four-cylinder balanced-compound engine of the 4:6:2 class to meet the above requirements. The dimensions are given in the accompanying table.

The first six-coupled balanced compound locomotives on this road were of this 4:6:2 class, having all four cylinders in the same horizontal plane and using the Stephenson valve gear with the eccentrics on the third axle. In these engines the inside (high-pressure) cylinders had bifurcated connecting rods spanning the front driving axle. A few years later, balanced-compounds of the 2:6:2 class were introduced for fast-freight service. In these, the inside (high-pressure) cylinders are inclined and raised to such a height as to permit a straight connecting rod to clear the front driving axle. They have the Walschaerts valve gear, actuated from the outside main crankpins. The arrangement of the cylinders, main rods and valve gear on these 2:6:2 engines proved so satisfactory as to lead to their application to the new 4:6:2 engines, thus retaining the desirable features of the earlier engines of this class, but eliminating the bifurcated connecting rods.

These features of the new engines being decided upon, the design was developed largely by the selection of parts common to existing engines and principally those of the two classes mentioned. Continued attention to details by the motive-power department had resulted in various improvements. Many of these had been introduced from time to time in revising and repairing existing engines, and thus had been given the test of actual service before being embodied in the new engines. In developing this new design the aim has been to adhere to the general features of the older equipment as far as practical, but to introduce such modifications as were necessary to overcome certain weak points which had been detected. This not only tended to retain equipment of a class with which the men are familiar, but provided an opportunity for the introduction of new and more powerful engines having a minimum number of new parts. The patterns have been taken almost exclusively from those common to former engines.

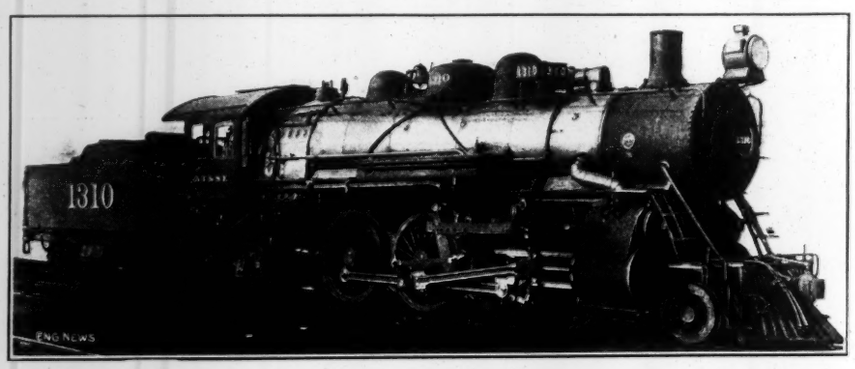


FIG. 1. FOUR-CYLINDER, BALANCED-COMPOUND 4:6:2 PASSENGER LOCOMOTIVE; ATCHISON, TOPEKA & SANTA FE RY.
(Baldwin Locomotive Works, Builders.)

CYLINDERS AND VALVE GEAR

The arrangement of the cylinders and valve chambers is shown in Fig. 2. Each pair of cylinders for each side of the engine is cast in one piece with a half saddle and the valve chamber for a piston valve serving the two cylinders. The center line of the valve chamber is 7 in. inside that of the low-pressure cylinder. The valve, Fig. 3, is arranged for high-pressure inside admission and outside low-pressure admission. It is of the type commonly used by the builders on balanced-compound locomotives. The steam pipes are on the outside of the boiler, so that joints are accessible for inspection and possible leaks will not affect the steaming of the engine. This is in accord with practice developed by this railway and applied to other recent locomotives.

The high-pressure (inside) cylinders are set approximately 2 ft. higher than the low-pressure cylinders, and in line with the valve chambers. They are at an angle of 7½°, as shown in Fig. 2. Their location makes it impossible to run the front and back flanges (which take the cylinder bolts) the full depth of the casting. To strengthen the joint, therefore, lugs are cast on the top of the saddle at the front and back, and two 1⅝-in. bolts pass through each lug. The opening in the smokebox is cut out sufficiently to clear the lug.

The outside and inside guides are shown in Fig. 4. The outside (low-pressure) guides are of the usual two-bar type, and are supported on cast-steel bearers which are bolted to a transverse yoke. The inside (high-pressure) guides are of the Laird type, this design being used in order to provide the necessary clearance above the leading driving axle. These guides are supported at the front end by the low-pressure guide yoke, and at the back end by a cast-steel frame brace, which is placed just behind the first driving axle and extends the full depth of the frame pedestals. The arrangement of high-pressure guides has resulted from the railway's experience in

overcoming cylinder-head troubles on older engines. The lengths of the inside and outside main rods are 8 ft. 4 in. and 9 ft. 2 in., respectively.

The crank axle is of the built-up type (Fig. 5) with cast-steel central web and forged-steel disks. The sections are pressed together and riveted over. Owing to the inclination of the inside cylinders, the inside and outside cranks on the same side of the locomotive are placed 187½° apart. The right-hand crank leads.

The valve motion is of the Walschaerts type. The links are carried on longitudinal bearers outside the leading pair of driving wheels, and rockers are used to transmit the motion from the combining levers to the valve rods. The rocker boxes are supported on the guide yoke, and the valve rods, which are necessarily short, are provided with knuckle joints. The rockers, and all pins used in the gear, work in bushings of Hewitt metal. The valves are set with a lead of $\frac{3}{16}$ in. on the high-pressure ports, and $\frac{5}{16}$ in. on the low-pressure ports.

The details of the valve-gear parts are among the many features which the railway has amended to overcome some of the annoying failures which often result from negligence of small parts. Care has been taken to avoid offset bearings in the valve motion parts, in order to minimize the tendency to twist or buckle. All pins are made of ample size and are arranged in double shear. Castle nuts of the Railway Master Mechanics' Association standard are used throughout the valve gear. Lubrication of bearings is carefully provided for by large cavities formed in the different members. No detachable oil cups are used on any part of the valve gear.

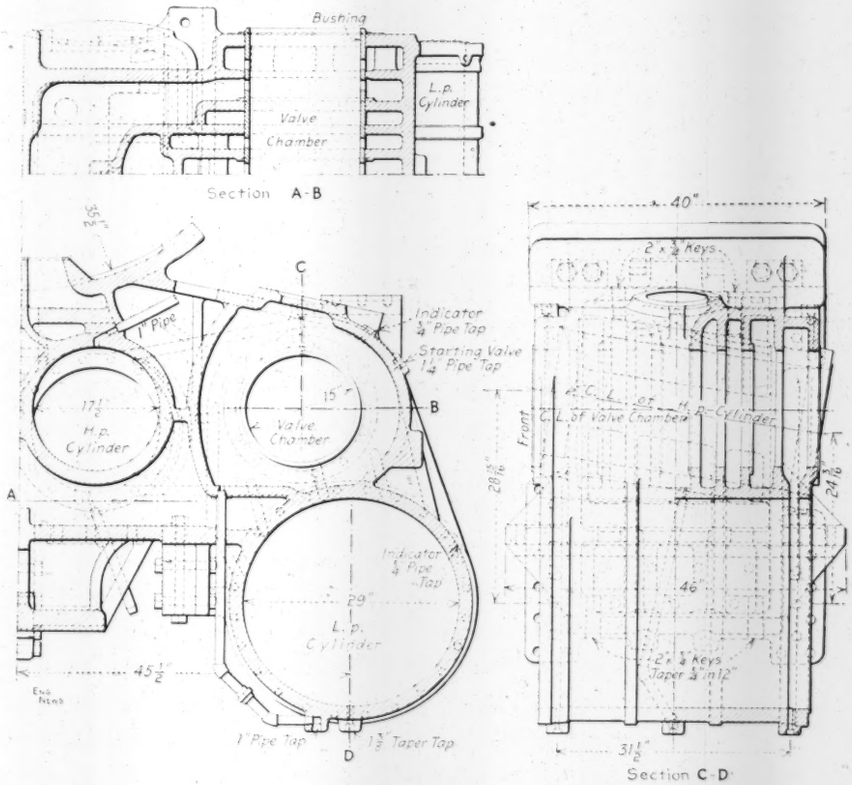


FIG. 2. CYLINDER AND VALVE-CHAMBER ARRANGEMENT OF BALANCED-COMPOUND LOCOMOTIVE

BOILERS AND FIREBOXES

The boilers on these new locomotives are of the wagon-top type, and have fireboxes of the Jacobs-Shupert type* in which the inside and outside shells are each composed of eleven steel channels riveted together through the flanges. All are fitted with superheaters. Six of the engines are equipped for burning oil, seven for burning Gallup coal (a light coal similar to lignite, mined in western New Mexico), and the other 15 for burning ordinary bituminous coal. On the 22 coal-burning engines the grates are shaken mechanically by a pair of steam cylinders placed under the boiler barrel and immediately in front of the firebox. Hand gear for shaking is provided also. In these engines a firebrick arch is used, supported on two 3-in. tubes extending from the lower part of the front water leg to the back water leg at a level above the fire-door. On the seven locomotives for burning Gallup coal the grate bars have fine fingers and narrow openings.

*Engineering News, June 17, 1909; Nov. 3, 1910.

The front-end arrangements for the coal-burning engines are shown in Fig. 6. For the engines burning bituminous coal, the netting extends diagonally from the exhaust nozzle to the top of the smoke-box, and an adjustable diaphragm extends across the smoke-box below the line of the netting. For the engines burning Gallup coal (lignite), the netting is run horizontally from the exhaust nozzle to the front of the smoke-box and then vertically to the top, as shown by the dotted lines. In all cases an adjustable draft pipe is placed between the exhaust nozzle and the base of the smoke-stack. The oil-burning engines are fitted with the equipment which is standard on this road, including the Booth burner. The firebox arrangement for these engines is shown in Fig. 7.

There are two steam domes on each engine; the rear one is placed on the wagon top, while the forward one is placed near the front end of the barrel. The latter contains the throttle valve, and has no direct communication with the boiler, the bottom of the dome being

DIMENSIONS OF FOUR-CYLINDER BALANCED-COMPOUND LOCOMOTIVES (4:6:2 CLASS); ATCHISON, TOPEKA & SANTA FE RY

Wheels; driving (6), diameter	6 ft. 1 in.
Front truck (4), diameter	2 ft. 10½ in.
Rear truck (2), diameter	4 ft. 2 in
Journals; driving axles, main (crank)	11x10 in.
Other driving axles	9 x12 in.
Front truck axles	6x10 in.
Rear truck axle	8x14 in.
Lateral play, driv. axles	½ in.
Wheelbase; driving	13 ft. 8 in.
Truck	6 ft. 8 in.
Rear truck to rear driver	10 ft. 0 in.
Engine, total	35 ft. 1 in.
Engine and tender	56 ft. 1¾ in.
Wheels having blind tires	none
Weight in working order;	
Max. on driv. axle	55,460 lb.
On drivers (ave. 53,633 lb.)	160,900 lb.
On front truck	54,980 lb.
On rear truck	60,620 lb.
Engine, total	276,500 lb.
Engine and tender (about)	448,000 lb.
Cylinders; high press. (2), inside	17½x28 in.
Low-press (2), outside	29x28 in.
Connecting rod, c. to c.; h.p.	8 ft. 4 in.
Low-press	9 ft. 2 in.
Valve gear	Walschaerts
Valves; piston, diameter	15 in.
Travel	5 in.
Throw of valve crank	14½ in.
Boiler; wagon top type; diam	5 ft. 10 in.
Plates, thickness	⅜ to ⅞-in.
Center line above rail	9 ft. 8½ in.
Smokebox, length	5 ft. 6½ in.
Working pressure	210 lb.
Firebox; Jacobs-Shupert	9 ft. 1¾ in.x6 ft. 3¾ in.
Depth	4 ft. 11½ in.
Crown, back and side plates	⅜-in.
Tube plate	½-in.
Water spaces; front and back	5 in.
Sides	5½-in.
Tubes; iron; No.	290
Diameter, 2¼-in.; thickness	No. 11 W.G.
Length over tube plates	18 ft. 2 in.
Heating surface; tubes	3088 sq.ft.
Firebox	223 sq.ft.
Arch tubes	14 sq.ft.
Total	3325 sq.ft.
Grate area	57½ sq.ft.
Superheating surface (Buck-Jacobs)	806 sq.ft.
Water in tender tank	9,000 gal.
Coal in tender	12 tons
Exhaust nozzle, diam	6 in.
Height to top of smokestack	15 ft. 8½ in.
Tractive effort	35,000 lb.

(LOCOMOTIVE: A. T. & S. F. RY.)

Wheels with blind tires	None
Max. driv. axle load	55,460 lb.
Lateral play of driv. axles	½ in.
Valves, travel	5 in.
Valve crank, throw	14½ in.
Exhaust nozzle, diameter	6 in.

closed by a plate. The domes are connected by a pair of 5-in. pipes within the barrel, and steam is thus taken entirely from the rear dome, which is at the highest point of the boiler and gets the dryest steam. The throttle takes steam through the top only, and delivers steam to the external dry pipe (Fig. 1). In all the engines an outside dry pipe runs from the throttle to the superheater and outside steam pipes run from the superheater to the valve chamber.

Superheaters

All the engines are equipped with superheaters, as noted above. In order to determine the relative merits of superheaters of the fire-tube and drum types, three of the oil-burning engines and two of the bituminous coal-burning engines are fitted with the Schmidt fire-tube superheaters, while the remainder have the Buck-Jacobs superheaters of the latest design in which the superheating

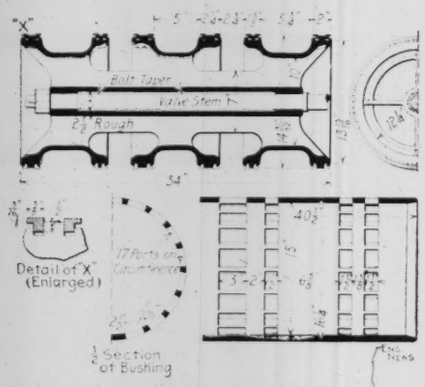


Fig. 3. Piston Valve and Bushing

chamber or drum is built into the boiler shell, and the products of combustion pass through the tubes to reach the smokebox. These different types of superheaters have been described in our columns.

In the engines having the Buck-Jacobs superheaters, the superheating chamber is 37 in. long, with its forward tube sheet 24½ in. back of the center line of the smokestack. An intermediate chamber is placed between the superheater and the main evaporating section of the boiler, and as this chamber can be entered through a manhole, the tube ends are easily accessible. The superheater tubes are welded into the tube sheet at the back end, and rolled at the front end. Steam enters the superheater on the top center line, and is guided by internal baffle plates so that it follows a circuitous course among the tubes. The steam leaves the superheater through right- and left-hand pipes which run direct to the steam chests and have their joints outside the boiler. The superheater section of the boiler is butt-jointed to the main boiler section, the joint being secured by an external covering strip taking four circumferential rows of rivets.

The superheater tubes are arranged in a manner which has proved most satisfactory, as far as the superheating of the steam and the draft of the boiler are concerned. The superheater is traversed by 350 tubes 2¼ in. diameter, 67 tubes 3 in. diameter, and one large tube 6 in. diameter. This last tube is placed just above the center line of the heater, and is applied to facilitate the removal of the boiler tubes. The 3-in. tubes are grouped in the lower part of the heater.

In the boilers, equipped with Schmidt superheaters, the front tube sheet is placed 50½ in. back of the center line of the smokestack. A large opening is cut in the smokebox shell, immediately above the header of the superheater, and this opening is covered by a saddle-shaped casting. There are three openings through this casting. The center opening communicates with the saturated steam chamber in the header, and the side openings wth the superheater chamber. The dry pipe and steam pipes are outside the boiler, and they communicate respectively with the saturated and superheated steam chambers in the header, by way of the openings in the saddle casting. The superheater is fitted with the usual arrangement of shut-off damper.

Frames and Spring Rigging

Carrying out the general scheme of adhering to its standard parts in the design of the locomotives, the railway has provided a frame which can be used with the present designs of shoes and wedges, driving boxes, etc. The strength of the frames has been increased, however, as compared with previous engines, and a satisfactory system of transverse frame bracing has been introduced. The frames are 4½ in. wide and are spaced 54 in. between centers. At the main driving pedestals they are offset ¾ in. outward, thus increasing the distance between centers to 45½ in. This is done to provide sufficient room for the crank axle and driving journals.

The frame rails over the driving boxes

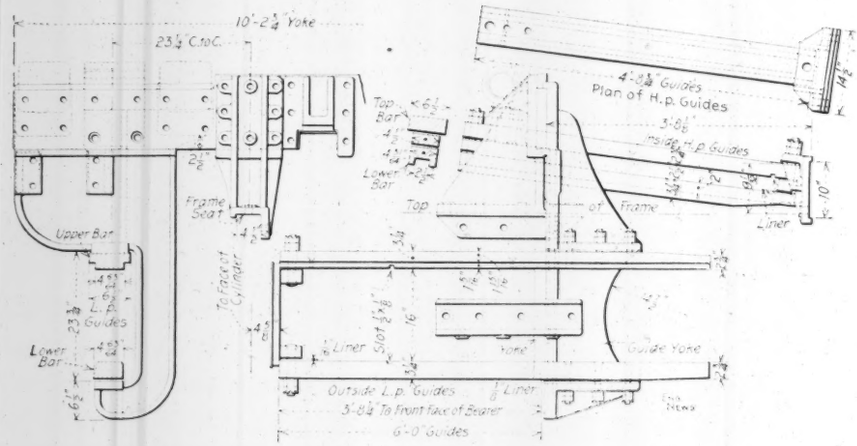


Fig. 4. Guides for Inside and Outside Cylinders

are 6¾ in. deep. Between the jaws the depth is 4¾ in. for the upper rails and 3½ in. for the lower rails. The front section of each frame consists of a single rail or slab 4½x10 in. under the cylinder saddle. This is joined to the

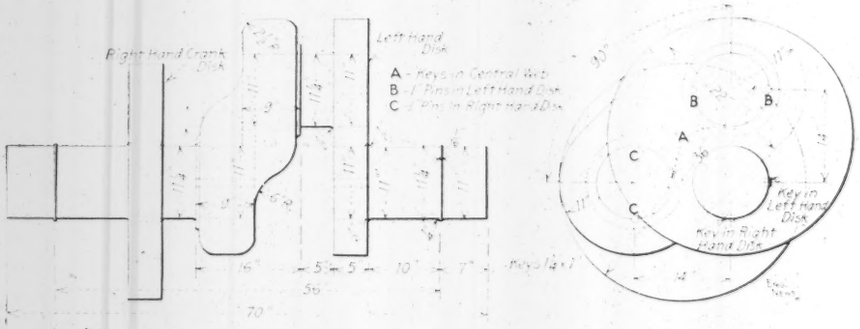

Right Hand Crank Disk
Left Hand Disk
A - Key in Central Hub
B - 1 Pin in Left Hand Disk
C - 4 Pins in Right Hand Disk
Key in Left Hand Disk
Key in Right Hand Disk

Fig. 5. Crank Axle for Balanced-compound Locomotive

main section by a specially designed connection. The rear section of each frame is in the form of a slab 2½x12 in.; these are arranged to accommodate the trailing

truck, which is of the Rushton type with outside journals.

The transverse frame bracing is worthy of mention. A broad steel casting spans the front rails just back of the cylinders and is bolted to the cylinder castings. This tie serves also as a support for the cylinders of the driving brake. The main sections of the frames are provided with three cast-steel braces. One is located just back of the front drivers, with a bearing 37 in. long on the top of the frame. This casting extends the full depth of the pedestals, to which it is securely bolted, additional metal being provided in the pedestals to include this bolting without weakening the frames. This brace supports the back end of the inside guides. A wide and deep casting is located between the main and rear driving wheels, being bolted to both the top and bottom frame rails. The third brace is placed at the juncture of the main and rear sections of the frames. This tie is located immediately beneath the cast-steel furnace bearer, to which it is securely bolted, thus making an unusually strong construction. The same arrangement of tie and furnace bearer is used at the back of the rear frame section, behind the trailing truck. In addition to these frame braces, the frames are further stiffened by plates connected with proper ties to the barrel of the boiler. These plates are secured at the lower ends to the steel frame braces.

The arrangement of the equalizing system and spring rigging calls for no special comment except the equalizer between rear driver and trailing truck. The design of this equalizer for the new engines was revised so as to place the bearings of all three pins in the same horizontal plane, thus eliminating the offset which tends to twist the equalizer.

All the driving springs are of the plate type (43 in. long). They are mounted directly over the driving boxes, and are connected by equalizing bars carried by hangers resting on the ends of the springs. The first hanger is anchored to the frame. The rear truck has a similar but larger (58-in.) spring over each axle box, and this is connected to the rear driving spring by a long equalizer carried by the hangers. A special attachment of the equalizer to the truck hanger provides for the lateral swing of the truck. This truck is not seated directly on the axle box, but upon a U-shaped yoke whose vertical legs are fitted to pins on rocker arms swinging from a bar which rests upon the box. Thus the boxes can shift laterally without affecting the springs. This yoke and spring can be seen in Fig. 1.

Tender

The tender is designed in accordance with the railway company's standard practice. Its trucks have arch-bar frames, with cast-steel bolsters and steel-tired wheels. The underframe is composed of 12-in. 40-lb. channels, and has the cast-steel end sills which are standard for all tenders on the system. The rear end-sill is provided with a drawbar carrier of cast steel, having lugs which interlock with similar lugs on the sill. When the carrier is in place, bolts are applied from the top, extending through the bottom wall of the sill and through the carrier. These bolts are for the purpose of preventing the carrier from sliding off the interlocking lugs and are subject to no stress from carrying the drawbar, as the interlocking lugs receive all the weight. Therefore, even though the nuts should become detached, the bolts will still remain in place and perform their work properly and no inconvenience from dropping of drawbar can be experienced. This carrier also has pockets located at either side of the drawbar carrying the center springs.

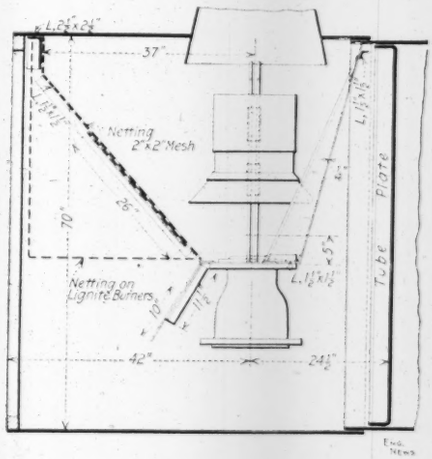


FIG. 6. SMOKEBOX AND FRONT-END ARRANGEMENT FOR ENGINES BURNING BITUMINOUS COAL

(For engines burning lignite, the adjustable bottom deflector is omitted and the netting diaphragm is placed as shown by the dotted lines.)

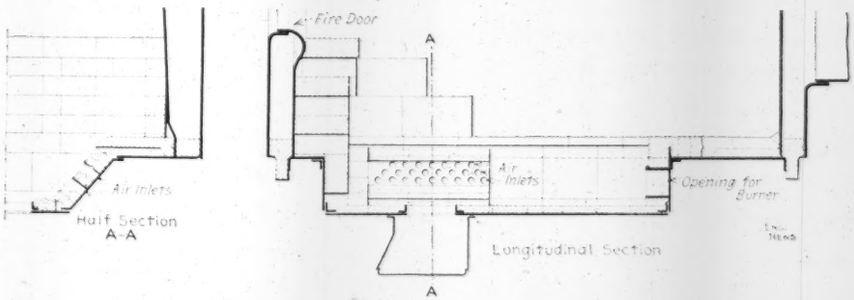


FIG. 7. FIREBOX ARRANGEMENT FOR OIL-BURNING LOCOMOTIVES

The Australian Capital Competition for the planning of a new capital city for the Commonwealth of Australia has called forth some 120 designs, many of these from America. The designs submitted are to be judged by a board of three men selected by the Council of the Victorian Institute of Engineers. Mr. James Alexander Smith, President of the Institute of Engineers of Victoria, and Mr. J. M. Coane, a surveyor, of Victoria, have been appointed as members of the board. The name of the third member, who is to be an architect, has not yet been announced. The conditions of the competition were explained in Engineering News, Sept. 28, 1911, p. 384. Three prizes are offered, amounting altogether to between $14,000 and $15,000.

In Starting Direct-current Motors of shunt or compound type, it has been found desirable to have full field excitation to prevent light torque, sparking and excessive rushes of current. It is also common to regulate the speed by inserting resistance in the field circuit, and where this interferes with proper starting it has been necessary to go to the trouble of cutting out the resistance first and cutting it in later to secure the desired speed. A device known as a "field-rheostat relay" has been developed by the Electric Controller & Manufacturing Co., of Cleveland, Ohio, to perform this duty automatically.

This relay consists of a solenoid through which a steel plunger passes carrying at its lower end a plate for electrically connecting two contact studs. The magnet coil and the plunger are inclosed in an iron case, which serves both for protection and as a part of the magnetic circuit. The coil is connected in series with the armature circuit of the motor, and the two contact studs are connected to the terminals of the motor-field rheostat so that the field resistance is short-circuited when the studs are bridged by the contact plate. The coil is designed so that when the armature current exceeds a predetermined maximum, the plunger is drawn up, causing the plate to bridge the studs and cut out all of the resistance in series with the shunt field. This gives the motor its full field strength and consequently maximum torque, enabling it properly to accelerate its load. As the current decreases, due to the speeding up of the motor, the relay plunger drops, replacing the resistance in the shunt-field circuit and weakening the motor field. This cycle of operation is repeated until the motor has been safely brought to the proper speed as determined by the setting of the motor-field rheostat.

Such a device, it is seen, permits of keeping the field rheostat set for the most desirable speed, of starting up properly and of always automatically reaching the desired speed. This saves the time of an operator in adjusting speed after each starting.

A Congressional Investigation of Scientific Management

For several months past a special committee of the House of Representatives has been investigating "Scientific Management" with reference to its proposed adoption in Government machine shops. This committee has just made its report. It approves the standardization of tools, machines and parts, the systematization of the work and its methodical planning; but with regard to the stimulation of the workman to increase his rate of work, the committee expresses doubt as to whether this may not introduce "the pace that kills."

Your committee has given especial attention to the Taylor system because we found that this system is being introduced in part in two government arsenals.

A great amount of good work has been done by Mr. Taylor and others in working out the details of scientific methods of shop management, but neither Mr. Taylor nor anyone else has presented to this committee a system so complete and perfect as to justify a recommendation that it be imposed in its entirety in any government shop.

Confidence is a plant of slow growth. Neither the Taylor system nor any other should be imposed from above on an unwilling working force. Any system of shop management ought to be the result of mutual conference and mutual consent. Government in a mill should be like government in a state—"with the consent of the governed."

The Taylor system of shop management may be divided into three general heads: Standardization, systematization and stimulation. Efficiency may be gained in whole or in part by any of these ways, by any two of them, or by all three combined. Any or all of these devices may be carried to an extreme. In the first two devices, namely, standardization and systematization, the expense which would be created by carrying them to an extreme would act as a check against the continuance of such a condition, but that check would not exist in that portion of stimulation which is applied to the workman.

The expenses of standardization and systematization are borne by the management, while the expense of stimulation in the form of increased energy is borne by the workman. Any system of shop management which creates a burden charge through standardization or systematization which is too heavy for the shop to bear or which imposes burden charges through stimulation which are too heavy for the workman to bear should be discontinued.

That there is some loafing or soldiering among workmen has been shown by the testimony before your committee, but it is not general nor does it occur in numerous instances compared with the total number employed.

Ordinary intelligent management under any system could eliminate it entirely, or at least reduce it to the point where it would not be a serious hindrance to production. Because there are some loafers is no reason why the remainder of the workmen should either be compelled or induced to work up to the very edge of the breaking strain. There is need for production at the lowest cost, but no economic necessity can justify requiring workmen to speed up to the highest point which they can continue from day to day and from year to year, even without injury to their health and strength. To place workmen in a position of that kind is to put them in the position of a beast of burden which is required to go on from day to day performing a given task.

There is a margin between the work performed by the loafer and the maximum task for a man, and in that margin lies a proper day's work. What constitutes a reasonable day's work can only be determined by practical experience and intelligent observation. It cannot be wholly determined by a stop watch or any other time-measuring instrument used only for a brief period of time.

By the stop watch you may be able to determine the time in which a piece of work can be done, but you do not thereby alone determine the length of time in which it ought to be done.

The time study of the operations of any machine can be made with a reasonable degree of accuracy, because all of the elements can be taken into consideration in making the computation. A machine is an inanimate thing—it has no life, no brain, no sentiment, and no place in the social order.

With a workman it is different. He is a living, moving, sentient, social being; he is entitled to all the rights, privileges, opportunities, and respectful consideration given to other men. He would be less than a man if he did not resent the introduction of any system which deals with him in the same way as a beast of burden or an inanimate machine.

In an effort to stimulate the workmen to increased activity various methods are used under different systems—such as discharge, fear of discharge, stop-watch time studies, and bonuses. The fear of discharge exists under any system and, no doubt, will continue to exist and to act as stimulus. The establishment of a premium or bonus presupposes the establishment of a task. The bonus system is based upon the establishment of a task large enough for an ordinary day's work and then giving additional compensation as an inducement to a workman to do more than he would ordinarily do.

The proponents of the Taylor system assert that the workman will be protected against any injustice either in the amount of work required of him or the compensation for that work by a change in the mental attitude brought about by the introduction of the system. A mental attitude which produces a spirit of coöperation between the employer and the employee is much to be desired, but such a spirit is not the result of any particular system of management, but is due almost entirely to the personality of the management and employee and the spirit that prevails in their relations to each other. Your committee is of the opinion that the mere mental attitude of the employer is too variable and unsubstantial a basis upon which to rest the material welfare of the wage worker.

Standardization

The Taylor system undertakes to standardize the tools, machines, nuts, bolts, etc., so as to eliminate as far as possible the loss of time and waste energy resulting from the lack of standardization. This is "a consummation devoutly to be wished."

Similar operations on similar work can be advantageously done in a similar way. It is a great waste of effort and thought to perform one operation in one way today and in another way tomorrow. But standardizing can be carried too far. When standardization has reached the point that the cost of maintaining it is greater than the saving resulting therefrom it should be discontinued.

Systematization

Any system that eliminates unnecessary and wasted effort is good. It does not necessarily follow, however, that because any particular system has been branded as scientific that the brand alone makes it such.

Conditions vary in different shops and a system which would be effective in one might not be as effective in another. The work and responsibility of selecting, evolving, or introducing a system suita-

ble to a particular shop must in a great measure depend upon the intelligence of the management.

The Taylor system undertakes to systematize the work first, by the establishment of a planning department; second, by detail study of the shop and the elements of a particular piece of work; third, by a routing system; and out of these grow a multitude of other details such as job cards, routing cards, time study, and many others. So much of this kind of detail work is needed under this system that it appears to your committee that constant care would have to be exercised in order to prevent the overhead charges thus created from using up all the benefits which might be derived from the proper systematizing of the work.

Planning

Every well regulated industrial establishment should have a planning department proportioned to the size and need of the shop. In establishing a planning department practical common sense should be used the same as in everything else. In a small shop the manager might easily be his own planning department. In large establishments a separate department could be utilized to advantage for the proper planning of the work.

Study of Details of Shop and Work

A detailed study of the elements of every piece of work for the purpose of discovering the best system of handling it and the elimination of unnecessary work on the part of the workman may be and no doubt is under some circumstances productive of good results. That is particularly true when unskilled men are selected to do skilled work and it becomes necessary to study their movements in order to train them to that standard of efficiency which skilled men have already attained; but it is neither as essential nor as beneficial where men are employed who are trained and skilled in the particular line of work they are expected to do.

Routing

It is always an advantage to have the work properly routed through the shop, although it is not at all times necessary that a routing card should be made out to accompany the work. In small shops the routing might be done very effectively by the oral direction of the foreman. In larger establishments routing cards are beneficial for the effective handling of the work and they are made more effective when the machines are properly arranged and grouped so that the work can pass through with as little handling as possible, but even in large shops where the same work is being duplicated day after day it would be a waste of time and an unnecessary expenditure of energy to furnish a routing card for any job after the work had reached the point where it automatically routes itself.

Stimulation

Here is the crux of the difficulty in the introduction of the Taylor or any other system of so called scientific management. So far as the workmen are concerned, they have not made any serious objections before your committee to standardizing or systematizing of the work, but they have vigorously protested against stimulation on the grounds that it tends to injure their health through overwork, and that while their wages may be temporarily increased, the result is that they are ultimately required to expend the greater amount of energy without receiving any additional pay.

In the judgment of your committee the best and most effective stimulus that can be given to the work in a shop is to secure and hold a fine spirit of coöperation with the management on the part of the workmen. That cannot be secured through timing the operations of the workmen with a stop watch when he considers such a procedure an indignity which recognizes him as being in the same class as a beast of burden or a machine, or when he considers such a time study inaccurate, and therefore unjust to him, or when he knows that it is to be used as a basis from which to compute the speed at which he must work and the wages he is to receive, when in his judgment the work, speed, and wage rate are being established in order to secure greater profits for the employer at the expense of the workmen.

A straight piecework basis may be used as a stimulus to workmen without injury to them on work that is continuously duplicated for a prolonged period of time, provided the workmen are so situated that they can protect themselves against the entire power of the management being centered upon them individually to compel them to work beyond their normal capacity, and provided, further, that they can secure a satisfactory guaranty that when the piece rate has been once established it will not be reduced unless the methods of production are materially changed, and reduced then only in proportion to the reduction in mental and physical energy required in the production of the article.

In any form that stimulation may be used, except that of true coöperation, continuous care must be had that quality is not sacrificed to quantity.

By mutual consent bonus and premium work may be introduced, but only with scrupulous care that the workman shall have full opportunity for increasing his earnings without risk of overstrain, for collective bargaining, if he should so desire, and for easy and direct appeal to the management in any cases where he may think his interests threatened.

The State Administration of Public Highways in the United States

In the early Colonial period, when the entire inhabited area of this country extended back only a few score miles from the sea-coast and when each community was nearly self-sufficient, highways of any length or degree of dependability were few and far between. Inter-city travel was very light, and traffic wherever possible was carried on by water. Such roads as were built were necessarily a local charge on the immediate community served. Assessments for their construction and maintenance were made upon the muscle, material and farm stock of the nearby residents, rather than on their pocketbooks.

There was thus established early in our history a system of local management of roads which has continued in many respects unchanged through two centuries.

During a half century or more previous to the development of the railway, there was a movement for state, and even national construction and administration of at least the trunk-line highways, and considerable activity in the building of turnpike toll roads by private enterprise. Both these lines of development were terminated by the coming of the railway, and the construction and administration of public roads lapsed to their original primitive condition.

With the growth of the country and the increasing need of some better roads, something had to supersede the old haphazard method where towns and "road districts" worked the roads. A system of county administration grew up in most of the states. Villages and townships cared for their own local streets and highways, but the county provided the funds and officials to build and maintain the main through highways.

The advent of the bicycle in the early 90's awakened a new interest in highway construction, and all over the country "good-roads" associations sprang into vigorous life. As a primary result of this campaign, a demand arose for engineers competent to build good roads. The "highway surveyor" who laid out and built the dirt roads, or even the county surveyor knew little or nothing concerning Telford or Macadam and their work. The need of some central authority to supervise road construction became apparent in many states.

In 1892, New Jersey enacted the first law authorizing state aid for good-roads construction. In the 20 years since then the idea has extended to nearly all of the states in the union, so that today over 60% of them have passed in some form or another laws under which the state has some part in the construction of public highways.

TABLE I. SHOWING STATE ADMINISTRATION OF HIGHWAYS IN THE UNITED STATES

STATE	STATE HIGHWAY ADMINISTRATION: NAME	COMPOSITION	CHIEF ENGINEER	DATE	DUTIES	FINANCES: MAX. PROPORTION BY STATE	METHOD OF RAISING FUNDS	REMARKS*
Ala.	State Highway Comm'n	State geologist, 2 professors, ex off.; 3 citizens, without salary	State Highway Engineer (employee)	1911	State aid and advice	½	$154,000 ann. out of convict fund	
Ariz.	Governor, etc.	Governor, auditor, ex off.; citizen, salary	State Engineer	1912	State aid and advice	———	Limited principally to convict labor	Convict labor
Ark.	None							All county work
Calif.	California Highway Commission	Committee under State Board of Engineers; 3 citizens, salary	State Highway Engineer (employee)	1911	State construction	All	$18,000,000 bond issue, 4%—50 years' final redemption	Purely a state system. Convict labor
Colo.	State Highway Comm'n	3 citizens, salary	Secretary and Engineer (employee)	1910	State aid and advice	⅓	Appropriation of limited sums	Convict labor. Largely advisory and experimental
Conn.	State Highway Comm'n	1 commissioner, appointed; salary	Deputy Commissioner (employee)	1907	State aid and advice	¼ to ⅓	$750,000 ann. (state bonds)	
Del.	None							State highway engineer for two of the three counties. County roads only
Fla.	None							All county work
Ga.	None							County roads with aid of state convict labor
Idaho	State Highway Comm'n	Governor, state engineer, state mining inspector, ex off.	State Engineer	1911	State roads and advice	All	Limited appropriations	State roads provided by special legislation only. Others under highway districts
Ill.	State Highway Comm'n	3 citizens, no salary; state engineer, ex off.	State Engineer (employee)	1906	Advice and experiment	———	$25,000 ann. (appropr.)	All county work. Convict labor from state
Ind.	None							All county work
Iowa.	Iowa State College of Agric. and Mech. Arts	6 professors, ex off.		1904	Advisory with demonstrations	———	———	All county work
Kan.	None		State Engineer	——	Advice and experiment	———	———	All county work. State engineer charges when advice is not accepted
Ky.	None							All county work
La.	State Board of Engineers	1 citizens, salary; state engineer, ex off.	State Highway Engineer (employee)	1910	State aid and advice	½	Taxes, Oyster fund and limited amounts	Convict labor
Maine.	State Highway Dept.	1 commissioner appointed; salary	State Commissioner of Highways	1908	State aid and advice	Variable	$250,000 ann. (appropr.)	
Md.	State Roads Comm'n	Governor, 2 members Geol. Survey, ex off.; 3 citizens, salary	Chief Engineer (employee)	1908	State aid and advice	½	$5,000,000 bonds (1908-13) 3½%, 15 yr.	Convict labor
Mass.	Mass. Highway Comm'n	3 citizens, salary	Chief Engineer (employee)	1892	State aid and advice	¾	$450,000 ann. (appropr.) bonds	
Mich.	State Highway Department	1 commissioner, elected; salary	Deputy State Highway Commissioner (employee)	1905	State aid and advice	Variable	$250,000 ann. (appropr.)	Convict labor
Minn.	State Highway Comm'n	3 citizens, no salary	State Engineer (employee)	1906	State aid and advice	½	$150,000 ann. (appropr.) direct state tax	
Mo.	State Board of Agriculture	Ex officio	State Highway Engr (employee)	1907	State aid and advice	½	———	Not very strong on state aid. Convict labor
Miss.	None							All county work
Mon.	None		State Engineer		Advisory only		No direct appropriation	All county work
Neb.	None							All county work
Nev.	State Prison Comm'n	Ex officio	State Engineer	——	State aid and advice	Convict labor only	$20,000 ann. (appropr.)	All county work except $20,000 ann. appropriated for convict labor
N. H.	Governor and Council	Ex officio	State Engineer	——	State aid and advice	½ (varies)	$125,000 ann. 30 yr. 3½% state bonds	
N. J.	Dept. of Public Works	1 commissioner, appointed; salary	Commissioner	1892	State aid and advice	⅓	$400,000 ann. (appropr.)	
N. M.	State Good Roads Commission	Governor, land commissioner, state engineer, ex off.	State Engineer	1909	State aid and advice		Direct tax	
N. Y.	Dept. of Highways	State engineer, state superintendent public works, ex off.; state superintendent of highways, appointed, salary	State Supt. of Highways	1911	State aid and advice	Varies	$50,000,000 bonds	
N. C.	N. C. Geologic and Economic Survey	Ex officio	———	1909	Advice and experiment		$5,000 ann. (appropr.)	
N. D.	None	———	State Engineer		Advice only	———	———	All county work
Ohio.	State Highway Dept.	Commissioner, appointed, salary	State Highway Com'r	1911	State aid and advice	½ to ¼	Direct tax	
Okla.	Dept. of Highways	Commissioner, appointed, salary	State Highway Com'r	1911	Advice and experiment		Auto. taxes	Convict labor
Ore.	None							All county work
Penn.	State Highway Dept.	Commissioner, appointed, salary	State Highway Commissioner	1911	State aid and advice	½	$3,000,000 (appropr.) state roads. $1,000,000 (appropr.) state aid	Very complete system of aid and advice
R. I.	State Board of Pub. Roads	5 citizens, no salary	Engineer (employee)	1902	State aid to towns	⅕	Appropriations and auto. taxes	Aid to towns, not to counties
S. C.	None							All county work
S. D.	None		State Engineer	——	Only state roads	———	Limited appropriation	Very limited
Tenn.	None							All county work
Tex.	None							All county work
Utah.	State Roads Comm'n	Governor, state treasurer, state engineer, 2 professors, ex off.	State Engineer	1909	State aid and advice	½ to ¾	$60,000 ann. (taxes)	Roads subsequently called state roads
Vt.	State Highway Comm'n	Commissioner, appointed, salary	Commissioner	1902	State aid and advice	½	$75,000 ann. (taxes)	Auto. fees go toward road maintenance
Va.	State Highway Comm'n	Commissioner, salary; 3 professors, ex off.	State Highway Commissioner	1906	State aid and advice	½	$250,000 ann. (appropr.)	Convict labor
Wash.	State Highway Board	Governor, auditor, treasurer, railway commissioner, ex off.; highway commissioner, salary	State Highway Commissioner	1905	Advice and experiment		Special tax	State aid law of 1907 repealed 1911
W. Va.	None							All county work. State Road Comm'n abolished 1911.
Wis.	State Highway Comm'n	State geologist, 1 professor, ex off.; 3 citizens, no salary	State Highway Engineer	1911	Aid and advice	Variable	$350,000 ann. (taxes)	
Wyo.	None							All county work. Convict labor

*Where the term "all county work" is used, there may be also township, district or other local highway administration, but no state administration whatsoever.

These laws vary within wide limits, but they may be roughly divided into two classes, those which provide financial and technical assistance to counties or towns undertaking good-road construction and those which merely provide advisory or experimental state bodies to disseminate information regarding good-roads construction. Out of the 48 states now comprising the union, 26 have passed laws providing for some sort of financial state aid for road construction, six states have advisory and experimental bodies, and the remaining 16 states have done little or nothing to promote good-road construction, save, perhaps, the furnishing of convict labor or the construction of roads in some state reservation.

Very few of the states have passed complete laws regulating highway construction, so that it is a difficult task to compile the various legislative acts and determine the exact status of the highway laws. For purposes of general comparison, however, we have prepared a table showing the extent of state aid to highways in each state of the union. This table, which is presented on the opposite page as Table I, has been compiled from the various state laws and from information kindly furnished by state officials. It gives for each state the name and duties of the person or body entrusted with the state's portion of road control, if such control exists; the title of the chief engineering officer of that body and his position as an independent state officer or as an employee of the body; the date of the organization of the present system; the proportion of the cost of state-aid highways borne by the state and the method of raising funds for state-aid purposes.

The financial-aid road laws vary greatly in their character, but their intention is, in all cases, to provide some body who can efficiently supervise the construction of those roads, of which part or all the cost is paid by the state. This administration is carried on by bodies of different names, make-up and method of appointment in the different states, and the money for their use is provided by direct taxes, by bond issues or by legislative appropriation of available funds. This money is distributed among the different counties by various *pro rata* methods as a portion of the total cost of road construction, the remainder of which is paid by the county. The state body decides where such roads shall be built, prepares their design, lets the contract and supervises their construction. The status of these roads when finished is variable. In some of the stronger state-aid states, the road becomes then the property of the state to maintain, and in the states where appropriations are smaller the finished road is turned over to the county for maintenance.

The 26 states which have adopted state-aid good roads may be further divided into two classes, in which the laws may be called "strong" and "weak," respectively. In the first class, which comprises Alabama, California, Connecticut, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Utah, Virginia and Wisconsin, 15 states in all, an extensive program of road building has been entered into and large sums provided either by bond issue or special appropriation. In all of these states well organized commissions have been formed and the entire supervision of public highways has been put in more or less direct charge of the state organization. The counties and towns may still carry on highway construction on their own responsibility; but the technical ability of the state commission is always at their service and financial assistance from the state funds is often available.

Eleven other states, Arizona, Colorado, Idaho, Louisiana, Missouri, Nevada, New Mexico, Ohio, Rhode Island, South Dakota and Vermont, render financial aid to their various counties, and, in the case of Rhode Island, towns; but their program is not so ambitious as in the states named above. All these states have commissions organized to take charge of state roads and having certain advisory powers and the right to conduct experiments, but the amount of money available for actual construction purposes is limited. Except for the fact that they do undertake a certain amount of actual highway construction with state funds, these commissions partake more of the nature of the advisory commissions, whose functions are described below.

The second class of state aid takes the form of so called advisory commissions, and is in force in Iowa, Illinois, Kansas, North Carolina, Oklahoma and Washington. These bodies have the same function as the United States Office of Public Roads, that is, to study the science of road construction by investigation and experiment and to advise any public body in the state upon questions of road design and construction. They prepare designs for roads and bridges and within limits are prepared to carry these out, provided the county or township defrays all expenses. In theory, each of these commissions or engineers, as the case may be, has the broadest possible powers of advice on matters of road and bridge design; but in practice it is soon found that the appropriations available will cover only a few of the problems that are submitted. In at least two of the states, however, very definite complaints have been lodged against the highway commission charging that the state body is taking away work from private engineers. As the laws creating those bodies grant them broad powers of advice, the extent to which this may be carried is only limited by the inclinations of the office holders and the size of the appropriation.

In these states the commissions also have charge of those bridges and roads which are purely state structures, and are further prepared to give advice on bridge construction where the bridges are along public roads. They prepare standard specifications and drawings for the design of bridges, which have proved most valuable to many communities, but here, as in the case of the highways, they have been at times criticized for taking work away from private engineers. Their defense is usually that the towns or counties soliciting their advice would never call in a private engineer, on account of the expense and that in time this free engineering advice, which, as has been said, is limited by available funds, will tend to show communities the need and desirability of engineering consultation in such matters.

A further duty of the commissions of both classes, and one that has not as yet been extended as far as it might or should be, is an inspection of all the bridges within the state with the view to insuring their safety. A commission provided with sufficient funds for inspection and ample powers of condemnation of bridges could prove a very effective guardian of the lives and limbs of travelers on the state's highways.

The personnel of the different commissions is extremely varied, as may be noted under the heading "composition" in the large table. For purposes of comparison the various types may be divided, as shown in the accompanying Table II, into *ex officio* bodies; bodies made up of state officers, *ex officio* members and of other citizens, the latter serving either with or without salary; bodies made up entirely of citizens, serving either with or without salaries, and those commissions made up of one commissioner and his assistants. The members of the *ex officio* bodies are, as a rule, the governor of the state with various members of his council, but in five states (see Table II) the recommendation of the U. S. Office of

TABLE II. SHOWING PERSONNEL OF VARIOUS STATE HIGHWAY COMMISSIONS

Ex-officio (8)	Ex-officio and citizens: No salary (1)	Ex-officio and citizens: Salary (4)	Citizens: No salary (4)	Citizens: Salary (4)	Single commissioner on salary (8)
Idaho	*Alabama	Maryland	Illinois	California	Connecticut
*Iowa		New York	Minnesota	Colorado	Maine
Missouri		*Virginia	RhodeIsland	Louisiana	Michigan†
Nevada		Washington	*Wisconsin	Mass.	New Jersey
New Hampshire					Ohio
New Mexico					Oklahoma
North Carolina					Penn.
*Utah					Vermont

*Includes professors from various colleges in the state. †Elected. All others in this class are appointed.

Public Roads in its model state-aid bill has been followed, and members of the faculty of colleges in the state have been called into service on the commissions.

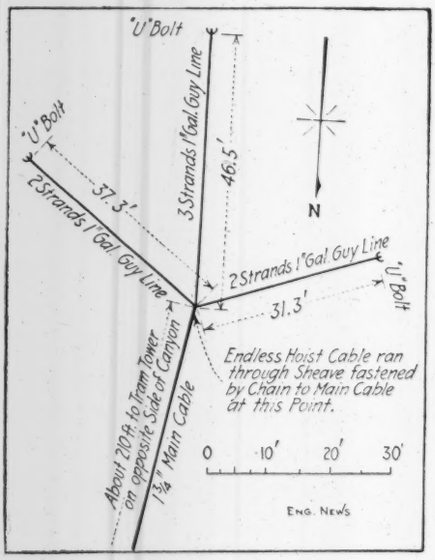
In the remaining 16 states, Arkansas, Delaware, Florida, Georgia, Indiana, Kentucky, Mississippi, Montana, Nebraska, North Dakota, Oregon, South Carolina, Tennessee, Texas, West Virginia and Wyoming, the states have no authority over, nor financial interest in, any but purely state roads, which are very limited in extent and cared for by various officials connected with the state government, but not devoted exclusively to highway matters. In Georgia and in Wyoming convict labor is contributed by the state to aid the counties, though in the latter of these two states even that aid is very limited. In Delaware there are state highway commissioners appointed for two of the three counties, but their duties in connection with state roads are very slight. Aside from these exceptions, all of the above-named 16 states cling to the old county, town or highway district administration, with officers for that administration a part of the local personnel, and with funds for road construction provided by the local body. The last column of Table I refers to all of these states as "all county work." This is a general term to cover all local administration, but in the majority of the states where no state aid has been extended, the county is the basis of highway control.

In nearly every one of these states, however, there is a marked agitation for the adoption of some state action with reference to good-road construction, and usually for financial aid. In a few states this agitation has reached the legislature in the form of a bill which may be expected to be enacted into law in the present year. Until such laws are passed, however, it will serve no useful purpose to record their contents here.

It is perhaps not necessary to note that the federal government appropriates no money for highway construction, except for the various federal districts, territories and reservations, and there the administration of the highways is under the authority of the heads of the various subdivisions. The United States Office of Public Roads is a bureau of the Department of Agriculture and is authorized by law only to carry on experiments in highway construction and to disseminate through the country such information as would tend to improve the quality of roads. A powerful campaign is being carried on by certain interests to secure federal appropriation of funds for highway purposes, and a number of bills to that end are pending in Congress; but the danger in opening the floodgates and allowing money from the national treasury to be appropriated for such purely local work as highway construction have been pointed out by President Taft and by other men prominent in public life.

The Cableway Accident at the Pathfinder Dam

A detailed account of the cableway accident at Pathfinder, Wyo., which was briefly noted in our issue of Feb. 22, is now available in the form of a letter from R. F. Walter, Supervising Engineer, U. S. Reclamation Service, Denver, Colo., to the Director of the Service at Washington, D. C. The accident occurred Feb. 9 at a time when the cableway was in use for transporting a load of concrete across the cañon of the North Platte River at the site of the Pathfinder dam. The guy lines, or anchor cables, by which the main tramway cable was secured to the


"U" Bolt
3 Strands 1" Gal. Guy Line
46.5'
"U" Bolt
37.3'
2 Strands 1" Gal. Guy Line
N
2 Strands 1" Gal. Guy Line
"U" Bolt
31.3'
Endless Hoist Cable ran through Sheave fastened by Chain to Main Cable at this Point.
About 210ft. to Tram Tower on opposite Side of Canyon
1¾" Main Cable
0 10' 20' 30'
ENG. NEWS

SKETCH TO SCALE, SHOWING ARRANGEMENT OF ANCHOR CABLES OF PATHFINDER TRAMWAY

(Sketch contributed by H. D. Comstock, Assistant Engineer, U. S. Reclamation Service, Pathfinder, Wyo.)

south wall of the cañon, suddenly snapped. Five men at work near the edge of the declivity were struck by the flying cables and fell to their death into the cañon.

The three anchor cables, after the accident, showed, in each case, a clean break close to their U-bolt anchorages. There is no information as to which cable failed first. Their arrangement is shown in the accompanying sketch.

Less than two days before the accident, the west guy line had been shortened to the length shown to shift the main cable toward the west, and the tramway had been in use in this position for not more than six hours. No computations of stress could be made since no definite information was available concerning the sag of the main cable.

An abstract of Mr. Walter's detailed account of the accident follows:

The accident at the Pathfinder dam, at 4:24 p.m., Feb. 9, 1912, was caused by the breaking of the anchor cables supporting a tramway on which concrete, equipment and supplies were transported across the cañon of the North Platte River, at the site of the dam, where the cañon is about 200 ft. deep.

The tramway consisted of a main cable, which was originally 1⅜ in., but which measured at time of accident 1⅝ in. The cable was anchored on the south side on top of the cañon by a crowfoot anchorage, consisting of three U-bolts placed in holes drilled into the solid rock, two of these being made of 1¼-in. hexagon steel and the other of 1-in. steel. When these U-bolts were put in, the ends were split before they were driven into the holes, which caused them to wedge at the bottom and prevented their pulling out. To two of these U-bolts were attached two strands of 1-in. galvanized guy cable, and to the third U-bolt three strands of 1-in. guy cable, making seven 1-in. strands in all, the other ends of these guy cables being attached to the tram cable.

At the time of the accident, this tramway was being used for transporting concrete across the cañon to a ladderway which was being constructed on the face of the south-side cañon wall. This ladderway was in the shape of a shaft, the cañon wall forming one side and the other three sides being inclosed by a concrete wall, the rungs of the ladder being of 2-in. galvanized pipe with the ends embedded in two of the concrete walls. The tramway was being used for the transportation of concrete used in the construction of this concrete wall and ladderway.

When construction of the ladderway was first begun, the main cable was pulled well over toward the east U-bolt so as to draw the tram line as far east as possible. The ladderway was then constructed to a point where the surface of the cañon wall made it necessary to make a slight detour from a straight line. In order to facilitate the laying of concrete at the top of the ladderway, on Feb. 7, two days before the accident, the lengths of the anchor cables were changed by letting out the east and taking up the west cable, so that the tram line then passed a little to the west of the center U-bolt.

The points on the guy cables which came in contact with the U-bolts were all changed when the anchorage was altered. Frequent inspection was made of the anchorage by the master mechanic, who had made his last inspection not more than 15 minutes before the accident, and everything so far as could be seen was in good condition.

At the time of the accident a skip, or pan, containing about 12 cu.ft. of concrete was being transported across the cañon. When it was about half way across, the anchorage cables suddenly gave way, allowing the pan and the south end of the tram cable to drop into the cañon. The ladderway had been constructed to the top of the cañon wall and the men were working on forms at the top of the wall under the cableway. It is supposed that the guy cables struck them and knocked them off, one man being entangled in the cables when found.

The master mechanic after finishing his inspection of cables had stepped down near the ladderway and was talking to the foreman. He states he heard one snap and was then knocked down by being struck with something, presumably one of the guy cables. The foreman was also knocked down and fell

close to the edge of the cañon wall but did not go over. Both the master mechanic and foreman received cuts on the backs of their heads. One of the workmen who was walking across the dam at the time of the accident states that the first thing he noticed was the cable and pan falling, then four men falling through the air. He looked away to avoid seeing them strike the bottom, and when he looked again he saw the fifth man just falling. Several men were working at the bottom of the cañon and rushed to the assistance of the injured men, but all were dead before they reached them, except one who was still breathing but unconscious, and who died a few moments later.

A coroner's inquest was held at Pathfinder, Wyo., on the morning of Feb. 10, and a very careful investigation was made to ascertain the cause of the accident, but no cause could be assigned. Careful examination showed that all guy cables used as anchor cables broke at the point of contact with the anchor bolts and all showed clean, new breaks, indicating that the cables were sound. No cable clamps had slipped and, except for the breaking of the guy cables, everything was whole and in good condition. It is estimated that, including the weight of the skip, concrete and cables, the load at the time of the accident was not over 3600 lb., which left a large factor of safety. The coroner's jury rendered a verdict of unavoidable accident.

What makes this accident more deplorable is the fact that it is the first fatality in connection with the building of the Pathfinder dam and that the ladderway was practically completed and work would have been finished and the men discharged in a few days.

Concentration of Water Power Control

The control of the water power of the United States is rapidly coming into the hands of a few great interests. A report on Water Power Development in the United States has just been issued by Herbert Knox Smith, Commissioner of Corporations, showing that ten great groups of capitalists control between them 60% of the developed commercial water power of the United States. Mr. Smith urges that all our available water power should be developed as promptly as possible since use of water power reduces the drain on the fuel supply, and also that a definite public policy with respect to public control of water power should be established.

*Abstract from a Report to the President by Herbert Knox Smith, Commissioner of Corporations.

Within the last decade, through the development of electric transmission of power, our water-power resources have come into national importance. Power from a single source can now reach a marketing area of at least 100,000 square miles. Water power, once strictly local, has thus suddenly been brought within the sweep of large economic forces. This report shows the results:

(1) An increasing concentration of the control of water powers by certain large interests.

(2) Extensive relationship between water-power interests, public-service companies (street railway, lighting, and power concerns), and banks.

(3) The need of developing our water powers as promptly and completely as practicable. Use of water power means conservation of fuel.

(4) The need for a definite public policy with respect to water powers. The effective means of applying such policy is through the control of the power site. It cannot be applied through fixing the price of water power independently of fuel power.

Total Developed and Potential Water Power—The total stationary power now used in the United States—steam, water and gas—is probably over 30,000,000 hp. Our total developed water power is about 6,000,000 hp. The bureau considered only developments of 1000 hp. and over. These amount to about 4,000,000 hp., and three-fourths of this is "commercial power" (power produced for sale). Unless otherwise stated, the power discussed herein is all "commercial," and is developed power (i.e., either actually installed or under construction).

Our water power now economically capable of development probably does not exceed 25,000,000 hp., including that already developed. Any such estimate is, however, necessarily approximate. The total developed and undeveloped is mainly in the Far Western States, the Lake States, and certain Atlantic Seaboard States.

Concentration Forces—There are three main causes of the consolidation of water powers.

First, economy in operation. A small water power, operated independently, rarely justifies the large investment usually necessary in transmission and distributing lines; but by "coupling up" several powers on the same transmission lines their use often becomes practicable.

Again, "coupled" power sites can supplement each other. One plant, lying idle in hours of low demand, can accumulate reserve "pondage" of water while the other serves the market.

Furthermore, the demand for power made upon a given power system usually comes from several different sources. By uniting different power markets much greater uniformity in this power demand is often obtainable and is obviously desirable.

Second, specialization in engineering enterprise. In this comparatively new field the expert knowledge of a few engineering, electro-equipment, and financial concerns tends toward dominance by such concerns.

Third, the elimination of competition. There is less opportunity for competition in water power than in most industries. The opportunity to eliminate competition by controlling the best power sites and the chief consuming interests is undoubtedly a factor in bringing about concentration of water powers.

Water power also tends to become the nucleus for a monopoly of both water and steam power. The great transmission and distributing systems necessary for important water powers are in themselves a naturally monopolistic factor. They are not likely to be duplicated by fuel-power producers. The water-power owners, on the other hand, if the water power cannot meet the entire power demand of the given locality, can construct or acquite auxiliary fuel plants and handle this power over the same distributing lines, and thus gradually build up a complete commercial power monopoly. Such, indeed, are the existing facts in a number of communities.

The actual effect of these great forces is now everywhere apparent.

Local Concentration—In California six great power corporations, of which the most important is the Pacific Gas & Electric Co. (with 118,343 hp.), together control 375,000 hp., over 86% of all the developed water power in the state.

In Washington two companies control 210,000 hp., or about 70% of all developed water power.

In South Carolina the Southern Power Co. owns about 101,000 hp., or 75% of the total commercially developed, with 73,000 hp. undeveloped.

In the Southern Peninsula of Michigan the Commonwealth Power, Railway & Light Co. controls 52,000 hp., or 73% of the commercially developed, together with probably 71,000 hp. more undeveloped.

Practically similar conditions exist in Montana, Colorado, Georgia, and at Niagara Falls.

Control by Interests—More important still, however, are the great groups of water-power interests. There are 10 groups of interests each controlling, or influencing through mutual directors and officers, over 50,000 hp., developed and

under construction. By far the widest sphere of influence is that of the General Electric Co., primarily an electric-equipment concern. The General Electric influence takes three forms: First, by absolute control; second, through interownership of stock and community of directors; third, simply community of directors. In the first class there are six companies, with about 83,000 hp.; in the second class 8, with 419,000 hp.; and in the third class 10, with 437,000 hp.; a total of 939,000 hp. of developed water power in 18 different states. In addition, this group controls about 640,000 hp., undeveloped, a grand total of over a million and a half horsepower.

Next are the Stone & Webster interests, which own or strongly influence 278,000 hp., chiefly in connection with public-service concerns. They exercise control, largely, through management rather than ownership, over 55 or 60 companies. Eight have water power, the largest being on the Mississippi River and in the Puget Sound region.

The other groups are the Hydraulic Power Co. of Niagara Falls, 144,000 hp.; the Pacific Gas & Electric Co., with over 118,000 hp. developed and the dominating factor in a large portion of California; the group known as the Clark-Foote-Hodenpyl-Walbridge interests, 104,000 hp., largely dominating the water-power situation in Michigan and also active in Maine and Oregon; the Southern Power Co., 101,000 hp., which owns the great bulk of the commercially developed power in South Carolina; the S. Morgan Smith interests (Georgia), 76,000 hp.; the Brady interests (Tennessee), 70,000 hp.; the United Missouri River Power Co., 65,000 hp., which, with the Butte Electric Power Co. (General Electric group), practically dominates the power situation in Montana; and the Telluride Power Co. (Colorado, Idaho and Utah), 56,000 hp. These last named nine interests also include under their influence 887,000 hp. undeveloped.

Thus 10 interests, excluding duplication, control or strongly influence 1,821,000 hp. developed water power, about 60% of the total commercial power in the United States, together with 1,449,000 hp. undeveloped.

Interrelationship of Large Interests—There is a still wider community of interest. Some of these great groups show more or less relationship with each other. The two greatest, the General Electric and the Stone & Webster groups, have directors in a number of the same corporations, and the S. Morgan Smith, Westinghouse, and Brady interests are similarly connected.

Water-power and Public-service Companies—There is, furthermore, an increasing affiliation of water-power concerns and public-service companies. The companies in the General Electric group control street railways in 16 towns, electric-lighting plants in 78, and gas plants in 19. Altogether, water-power or allied companies own or control and operate street railways in 111 towns, electric-lighting plants in 669 towns, and gas plants in 113 towns.

The reasons for this are obvious. Control of the chief consumers of power both assures a market for power and excludes others. This connection between great power groups and the agencies that directly serve the public is of serious public significance.

The whole concentration movement is still going on. This report has, as far as possible, been brought up to date, but since it went to press new mergers have occurred.

Interlocking Directorates—A more general relationship, of a sort not peculiar to water power, but nevertheless of broad public significance, is best illustrated in the General Electric Co. Men who are officers or directors in that company, or of its three wholly controlled subsidiaries, are also officers and directors in many other corporations. These other companies, with their subsidiaries, and with the General Electric and its subsidiaries, make a far-reaching group thus interconnected by active personal and financial relationship. This one group of interrelationships controls or influences 24 corporations that operate hydro-electric plants; over 50 public-service corporations, not counting as many minor subsidiaries; and, finally, this one group of interrelationships includes numerous railroad and industrial corporations, and over 50 banks and financial houses, many of them in the first rank of importance. About 20 "General Electric" men in all constitute most of this chain of connection, three of these being members of the firm of J. P. Morgan & Co., which is generally regarded as the dominant interest in the General Electric Co. These connections in no sense always mean control by the General Electric Co., or even identity of policy. They do, however, mean a striking degree of community of interest.

Resulting Public Issues—This great concentration movement is in a field where the public is peculiarly interested. Power is at the foundation of modern industry. The facts raise these questions: (1) The best development of our water-power resources; (2) the protection of the consumer; (3) the securing for the whole public of its proper share in the advantages inherent in the natural resource itself.

The need for water-power development is obvious. The nonuse of water power means the diminution of our other sources of power. The water power now in use saves at least 33,000,000 tons of coal annually.

Prompt utilization is therefore essential. But it must be frankly recognized that the most efficient use of water power requires a considerable degree of unified control. Certain highly monopolistic tendencies are inherent in the water-power industry, largely centering around the expensive fixed investment in transmission and distributing lines.

Our public policy must recognize both the need for utilization and the dangers of monopolistic control and take effective action on both. It must also recognize the close relation and possible conflict between water power, navigation and irrigation.

One very important fact must be emphasized. The point at which such effective public safety must be applied is the power site itself. The public cannot be protected by any attempt to fix by law the selling price of water power *by itself*. Nor can any such method secure for the public its due share in the natural resource. Fuel power will substantially fix the price of all power, because there is practically no considerable area in the United States where water power can supply the entire demand for power. Of course, water power cannot be sold above the price of fuel power. On the other hand, if the price of water power be fixed by law below that of fuel power, not all the community, in most instances, can be served with the cheaper power, and an unfair discrimination must result. If we take water power by itself, there is, broadly speaking, but one effective method of control, in so far as the power sites are still public property. The public can either develop and operate the site, selling the energy at market rates, or the public may lease the site at a rental fairly representing its natural value. In either case the public treasury will get the profit due to that natural value. There may be certain exceptional instances which would justify the outright sale of public power sites. The rental system, however, presents distinct advantages—foremost of all, that of retaining in the public hands the ultimate control of the resource. Assured public control is peculiarly desirable, because, broadly speaking, water power is inexhaustible and permanent, and therein differs from almost all the other natural resources, which are expended in their using.

Finally, whatever form of public action is taken, that action should be immediate—first, to save our fuel by the use of water power, and, second, because our remaining public water powers are fast passing into private control, making regulation thereafter difficult.

An Appropriation of $25,000 has been made by the City Council of Cincinnati, Ohio, to be used in an investigation of the sewerage system of that city with a view toward providing sufficient topographical data from which the design of a new system may be made. At present there is no unified system of sewerage in this city, and any additions which are made must be only to serve the immediate house or houses for which they are built.

Letters to the Editor

Further Notes on the Spang-Chalfant Reinforced-Concrete Building Failure

Sir—In the interest of accuracy and to throw additional light upon the failure of the Spang-Chalfant building, I wish to state that while the sketch shown in ENGINEERING NEWS, Mar. 14, 1912, p. 498, is according to the contract plans, there was a subsequent change made in the plans. A column was added between Nos. 92 and 93. This, of course, practically doubled the load on column 97. This latter column had originally one concrete pile under it. When the change was made a spread footing was added on top of this pile. A load of 140 tons on a spread footing in filled ground and one pile did what would be expected of it: it forced the column down something over 1¼ in. This appears to have been the thing that tripped off the wreck. Column 104 next spalled on the corner toward 97; then 108 buckled in the middle.

The floor details on p. 499, while they were on a drawing of the "Second Floor," are really details of the first floor. The second and third floors and roof are of the same character of design, but the slabs are only 4 in. deep for the middle 10 ft. with ⅜-in. rib bars spaced 4¼ in. c to c. The gallery floor, which is at the second-floor level, is the same as this first floor of the office building.

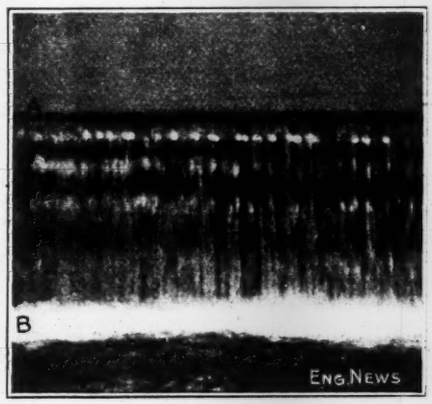
EDWARD GODFREY.

Pittsburg, Penn., Mar. 16, 1912.

The "Breathing" of Water Falling Over a Dam

Sir—The accompanying photograph may be of some interest to your readers. It represents the fall of water over a portion of the dam in the Licking River at Zanesville, O., and the purpose of the photograph is to show the "breathing" or undulations in the sheet of falling water. The point *A* represents the crest of the dam, and *B* the point where the water strikes the bed of the stream. The height is about 8 ft.

It will be noticed that the pool of water above the dam was as smooth as glass at the time the photograph was taken. The sheet of water falling over the crest is something like 2 in. thick. The dark and light portions of the sheet of falling water represent the undulations which travel from the crest of the dam to the bed of the stream and which grow further



UNDULATIONS IN THE SHEET OF WATER FALLING OVER A DAM (HEIGHT, 8 FT.)

apart as they near the bottom. The fall of water is vertical over a sharp crest and, at this stage, gives forth a sound resembling the open exhaust from a small slide-valve engine running at, say, 150 r.p.m.

J. F. JACKSON, Vice-Pres.,
Milwaukee Bridge & Iron Co.

Milwaukee, Wis., Mar. 14, 1912.

More Concerning Mr. Elliott's Dismissal: The Engineering Plans for Draining the Florida Everglades

Sir—I have read the editorial in your issue of Feb. 22 concerning the dismissal of C. G. Elliott from the office of Chief Engineer of the United States Drainage Investigations, and note that it contains one statement which is not entirely correct. The editorial gives the impression that the irregularity charged against Mr. Elliott was borrowing money from private persons to continue a survey and then replacing this out of the next year's appropriation.

The facts of the case, however, are these: For the year 1909, Congress appropriated a lump sum to be equally divided between Drainage Investigations and Irrigation Investigations. Mr. Elliott's superior made him a statement in the usual manner, of the amount of money which would be available for his use during this year, after the necessary amounts had been withdrawn to pay for administration. Mr. Elliott *kept within his appropriation for the year*, and at the close of the fiscal year on June 30 had spent about $800 less than the amount appropriated to his division. Early in July, Mr. Elliott's office was informed, during his absence in the West, that the Office of Irrigation Investigations had overspent its appropriation and that on this account a part of the bills incurred by Mr. Elliott's office could not be paid. An official of Irrigations Investigations has stated that their appropriation had not been exceeded, but that the fault lay in the general administration, for which neither of the two offices was responsible. The accountant for the Office of Experiment Stations, of which the Drainage Investigations is a branch, suggested the arrangement for covering the deficiency which was described in your editorial. These suggestions were forwarded to Mr. Elliott by mail, and he acquiesced in them, as having the authority of the Accounting Department. On his return to Washington, he signed the necessary papers which had been prepared for him. Thus not only did Mr. Elliott not profit personally by any breach of red tape, but such a breach was the direct result of the failure of his superiors to furnish him with the funds which had been appropriated for his office by Congress.

As is known to everyone connected with the case, there is a close connection between Mr. Elliott's dismissal and the suppression of certain reports on the reclamation of the Florida Everglades. One of Mr. Elliott's subordinates prepared a report on the drainage of the Everglades. At this time Mr. Elliott had confidence in this assistant and the report was allowed to go to press without his examination of the engineering features. While it was being prepared for printing an examination was made and it was found that the report was more favorable than was justified by the facts, and that Mr. Elliott's instructions concerning the capacity of channels and other features had not been carried out. Mr. Elliott therefore rewrote the engineering features of the report and asked to have this published in place of the original. The printing of this amended report, and of a preliminary circular outlining conditions in the Everglades, were objected to by persons interested in selling Florida lands. The circular was suppressed, and the report was never issued.

Previous to this time, however, the engineering features of the original report, containing all of its faults, had been made public, and for two years have been used by land-promotion companies as advertising literature. One real estate man purchased about one million acres of land in the Everglades, agreeing to pay

$2 per acre for it in installments. A large part of these lands have been sold in tracts of about 10 acres for from $24 to $80 an acre. The total amount paid out by the purchaser, in advance of beginning the sale of the lands to small purchasers, was less than $100,000.

During 1911, a resolution was passed in the United States Senate providing for printing a number of public documents concerning the State of Florida. The United States Office of Drainage Investigations was called upon to furnish its report on the drainage of the Everglades. The revised report, as prepared by Mr. Elliott was furnished, but before being printed, it was sent to Florida *where it was replaced by the original report containing the inaccurate engineering statements*, and this unamended report was printed, with other data, as Document 89, 62d Congress, 1st Session. The data for Senate Document No. 89 were collected and arranged by an employee of the Everglades Land Sales Co.

I would like to draw your attention to some of the engineering features of this report:

Under the subject Evaporation, the author of this report, J. O. Wright, gives his reasons for depending upon an evaporation of 0.3 in. in 24 hours for the space of two months during the summer, during which time the rainfall will amount to 24 in. On p. 167, under the heading Run-Off, the author states that the difference between rainfall and evaporation is the run-off or drainage that must be provided for. He assumes that the theoretical evaporation of 0.3 in. per day would actually take place over the entire watershed for the entire 60 days of the period under consideration, and that where the average daily rainfall for two months is 0.387 in. and the evaporation 0.3 in., that the average run-off would be 0.087 in. He makes no provision whatever for excessive run-off after extreme storms, which may amount to 7 in. or more in 24 hours, according to the rainfall tables submitted.

It is interesting to compare these statements of evaporation with the records of evaporation at Lake Tahoe, California (as given in the last number of ENGINEERING NEWS), where the rainfall is very much less and the maximum summer temperature is somewhat greater. A comparison shows that the evaporation estimated by Mr. Wright during summer months having 12 in. of rainfall is approximately double that observed on Lake Tahoe. As Mr. Wright sees the situation, 75% of the maximum rainfall for these two months will be evaporated. He assumes to provide storage capacity in Lake Okeechobee for 20%, leaving only 5% to be carried by canals from Lake Okeechobee to the Gulf, in order to prevent the overflow of the lake or its rise above a stage of 19 ft. above sea-level. Should he have made a mistake in estimating the evaporation so that only 70% of the rainfall will be evaporated instead of 75%, his canals will have but one-half the necessary capacity. Should he have made a mistake of 50% in the evaporation, as seems possible, the canals will have to have about seven times the capacity now provided.

There are other questions which will occur to the engineer reading this report. If 75% of the rainfall of the two wettest months is evaporated, then doubtless all of the rainfall of the drier months will be evaporated and the Everglades will have more the appearance of a desert than of a swamp. With such a high rate of evaporation it would also be assumed that at the beginning of the wet period there would be considerable storage capacity in the loose muck soil of this drainage area, and that all of the excess of rainfall over evaporation would be absorbed, leaving no run-off whatever.

Leaving the subject of evaporation, we come to the design of canals planned for carrying the water. The entire plan is based upon the supposition that during the dry season the water level in Lake Okeechobee is to be gradually lowered to an elevation of 16 ft. above sea level and that during the wet season it is to fill up to an elevation of 19 ft. above sea level. The surface of the ground around the lake is 21 ft. above sea level, leaving the water standing within 2 ft. of the surface during high water. On page 179 of this report the statement is made that after the muck lands have been drained a settlement of the surface will probably take place equal to about one-half of the depth of the present surface to the permanent water-table, the amount varying with the composition of the muck. If such a settlement of the muck takes place south of Lake Okeechobee, the water in the ditches during the wet season will be just about at the surface of the ground.

Referring to the tables on pages 169 and 170, it is seen that the depth of flow of each of the canals is estimated to be 2 ft. less than the depth of cut. That is, the surface of the ground being 21 ft. above sea level, the surface of the water is 19 ft. above sea level. It is noticeable that Mr. Wright has estimated the capacity of his canals at the highest stage of water in Lake Okeechobee, whereas the depth of flow at the beginning of the storage period will be 3 ft. less than that indicated. In all canals except the first two, the maximum depth of flow is 5 ft., so that the depth during the beginning of the storage period will be 2 ft., and the mean capacity of the canals from the beginning of the storage period until the lake should reach an elevation of 19 ft. above sea level, will be only about 55% of that estimated by Mr. Wright.

In the second paragraph on page 169, Mr. Wright states his basis for estimating the run-off from the land which will be in cultivation in the Everglades, if this development is a success, at a uniform rate of 90 cu.ft. per sec. from each township; that is, the total run-off for the 60 days in this area is the difference between 24 in. of rainfall during that period and 18 in. of evaporation, and this run-off is estimated to be absolutely uniform throughout the two months and over the entire area, although rainfalls of from 5 to 7 in. in 24 hours may occur.

Another fundamental feature in this plan is the provision for using the same canals for carrying the water out of Lake Okeechobee and for irrigation. During about six months of the year the rainfall is frequently so light that crops cannot be raised without an abundant supply of water by irrigation. By referring to the rainfall tables the difficulty of using these canals both for drainage and irrigation will be seen. For instance, if it were assumed that the wet season is over by Nov. 1, and the water in the lake is retained, to be let out gradually for irrigation purposes, in case of a month like December, 1905, when 15 in. of rainfall occurred, there would be no storage capacity in the lake to receive it, and the Everglades would be flooded. On the other hand if it were assumed that storage capacity must be provided for until January, for a period like that from October, 1903, to June, 1904, when the rainfall was not sufficient for growing crops, the lack of a supply of water in Lake Okeechobee for irrigation purposes would be fatal to agriculture depending upon it.

These are only a few of the remarkable deductions included in this report, but perhaps the most remarkable fact is that the state authorities and the purchasers of this land, knowing that the Chief Officer of the United States Drainage Investigations office, a man of national reputation in his field, had disagreed with his subordinate, who was comparatively unknown as an engineer, concerning the proper plan to be followed in this reclamation, should have adopted the plan of the subordinate; should have let contracts for $2,000,000 worth of construction work, and should have sold Everglade lands in 10-acre tracts, to tens of thousands of persons of small means throughout the United States, at prices ranging from $25 to $80 per acre, without having their plans passed upon by the most responsible consulting engineers. It is also noticeable in this connection that Mr. Elliott's dismissal was made upon the complaint of Mr. Wright, who since leaving the United States government service has had charge of the plans of the development of the Florida Everglades in the employ of the State of Florida.

I was in the service of the United States Drainage Investigations as Supervising Drainage Engineer for three years, including the time of the preparation of this report.

ARTHUR E. MORGAN.

Memphis, Tenn., Mar. 11, 1912.

Issued Weekly by
The Engineering News Publishing Company
JOHN A. HILL, Pres. CHARLES WHITING BAKER, Sec'y.
ALFRED E. KORNFELD, Vice-Pres. W. W. MAYER, Treas.
GEORGE H. FROST, Chairman Board of Directors.
505 Pearl St., New York.
1138 Monadnock Block, Chicago.
Home Life Building, Washington, D. C.
Z. P. Maruya & Co., Ltd., Tokyo, Japan.

CHARLES WHITING BAKER, M. N. BAKER,
E. E. R. TRATMAN, F. E. SCHMITT,
Editors.

Subscriptions payable in advance, $5.00 a year for 52 numbers, including postage in the United States, Mexico, Cuba, Porto Rico, Hawaii, or the Philippines, $7.00 in Canada.

To foreign countries, including postage, $9.00 or its equivalent, 36 shillings: 36 marks: or 45 francs.

Notice to discontinue should be written to the New York Office in every instance.

Advertising copy should reach New York Office by Thursday of week before date of issue.

Entered at New York Postoffice as mail matter of the second class.

CIRCULATION STATEMENT

During 1911 we printed a total of 931,958 copies.

Of this issue, 19,000.

None sent free regularly, no returns from news companies, no back numbers kept beyond current year.

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Engineering News

Sewage Purification Experiments at Cleveland, Ohio

Cleveland, Ohio, has done well in deciding to establish a large working-scale experimental sewage-purification plant, as announced in more detail in a brief note which appears on page 618 of this issue. The light that such a plant will throw upon the local sewage-disposal problem will be of great assistance in deciding to what extent the burden of sewage disposal by dilution at Cleveland should be lightened by clarification. In addition, many times the cost of the experimental plant may be saved by the proposed experiments.

Should it finally be proved that a relatively small degree of clarification is sufficient to meet the local conditions of the present and near future, the experimental work will prove all the more profitable an investment, since it will not only save or postpone a large outlay, but will also allay the apprehensions of many who would otherwise think that much was being left undone that demanded immediate action. Should the experiments, combined with data from other sources, lead to the conclusion that relatively comprehensive works are needed, then the data gained by the experiments will be all the more valuable as a guide in designing works. In any event, it is better to experiment before than after building sewage-treatment works. An article on the intercepting sewers of Cleveland appears on pages 586-9 of this issue.

An Investigation of Scientific Management

As some of our readers may recall, the attempt to introduce the Taylor system into some of the shops connected with the Government Ordnance Department, some time ago, led to vigorous protest on the part of the workmen and a threatened strike.

The matter was brought to the attention of Congress, and by a resolution last August the House of Representatives ordered a special committee to investigate scientific management, made up of W. B. Wilson, of Pennsylvania, who is chairman also of the House Committee on Labor, and who has had a prominent career in connection with labor organizations in the mining field; William B. Redfield, of Brooklyn, and John Q. Tilson, of New Haven. Mr. Redfield has long been prominent in the machinery manufacturing field, and is now vice-president of the American Blower Co. Mr. Tilson is a prominent lawyer of New Haven.

The committee devoted much time to an investigation of scientific management as applied in various shops, and gave hearings to those interested in the promotion of various systems of management.

The report of this committee, presented in summary elsewhere in this issue, seems to us to agree admirably with the estimates of scientific management which have been presented editorially in these columns. The committee frankly recognizes the excellent features in the methods of standardizing and systematizing manufacturing processes which have been developed by Mr. Taylor and his assistants. Coupled with this approval is a needed caution that what will suit one shop will not suit another, that the system and routine which is necessary in a large shop is a useless expense in a small one and that scientific management, like everything else in an industry which is carried on for profit, must save more than it costs or it is not worth while.

The chief opposition to the introduction of scientific management has come from the workmen, who have protested against being made mere machines and also against the speeding-up process on the ground that it was calculated to produce a pace which only the strongest could survive for any length of time. This protest is, to a certain extent at least, justified, as can be shown by quotations from Mr. Taylor's own writings, where it is recounted that a "weeding out" of the men employed was one of the first things necessary to obtain those who could stand the pace.

The committee in presenting its report practically condemns this part of the Taylor system. It points out that intelligent and hearty coöperation between the workmen and the employer is essential to economic as well as efficient production. With all the aid that systematic testing and inspection systems can afford, it is not possible to so *drive* a set of discontented and dissatisfied workmen that they will produce a maximum amount, and at the same time not sacrifice the character of the product in quality of workmanship.

The committee is to be commended for the breadth and judicial character of its report. It is worth careful reading and study, not only with reference to work carried on by the government, but to private industry as well, for the principles which the committee lays down are as applicable to shops carried on by private enterprise as to those which the government carries on.

The Engineering Plans for Draining the Florida Everglades

In our correspondence column this week we give space to a letter from Arthur E. Morgan, of Memphis, Tenn., reciting some further facts in connection with the recent dismissal of C. G. Elliott from the office of Chief Engineer of the U. S. Drainage Investigations. Our readers will recall that we have given some attention to this matter in these columns because it seemed to us that substantial injustice had been done to a prominent engineer and in a way which was calculated to injure not only his own reputation but the general reputation of the profession.

Another aspect of the case is brought forward in Mr. Morgan's letter, and that is the possible connection between Mr. Elliott's dismissal and the promotion of land sales in the Florida Everglades. The claim is made that the reason back of Mr. Elliott's dismissal was that he had tried to prevent his department being made use of by promoters who were selling Florida Everglades land to "suckers." This matter is now being investigated by the Congressional Committee on Expenditures in the Department of Agriculture, and in order to get some idea of the question at issue we have waded through—we use the term advisedly—a thousand odd pages of the hearings which have been in progress for a month past before this committee.

We shall not consume valuable space nor take our readers' valuable time by presenting even a summary of this investigation, which, like most such investigations and like most judicial proceedings at the present day, defeats its own ends by the extraordinary length to which it is drawn out.

It is proper, however, to call attention in this place to the engineering plans for draining and making cultivable and habitable the Florida Everglades. It has been testified in the investigation that thousands of people all over the country have purchased small tracts of land in the Florida Everglades, at prices from $20 to $80 per acre. They have made these purchases on the strength of assurance that the State of Florida was proceeding with the work of draining these lands, and that they will soon be reclaimed.

It has been developed by the investigation that the plans on which this drainage work is now being carried on are challenged as to their engineering soundness. The State of Florida has placed this drainage work in the hands of J. O. Wright and is carrying out plans for the work made by Mr. Wright, and which rest entirely on his unsupported authority.

Mr. Morgan, in the letter published elsewhere in this issue, makes certain criticisms of these plans which speak for themselves. We shall not take space here to review these plans in detail further than to present one single fact which, to an engineer, speaks volumes as to the reliability of the plans under which the State of Florida is now proceeding. It is of record that Mr. Wright's estimate of the cost of this work involving quantities of about 8,000,000 cu.yd. of rock excavation under water and about 31,000,000 cu.yd. of earth excavation, was *eight cents per cubic yard* for rock and *four cents per cubic yard* for earth. If there is any place on earth where rock of any sort in any position has been excavated at a cost even approaching this figure, we have never heard of it. The actual contract prices at which the work was let in June, 1910, were 8c. per cu.yd. for earth and 20c. per cu.yd. for rock. Even these prices will be questioned by many engineers, we believe, as not representing the entire cost of performing the work.

We need carry the criticism no further. It is evident that the State of Florida has undertaken a large engineering enterprise without any proper assurance that the engineering problems in connection with it had been studied and correctly solved. We give notice now that if the present work is carried to completion and the expected results are not secured, the blame must not be laid on the engineering profession.

What the State of Florida should do is to stop all work now in progress and submit Mr. Wright's plans for the Everglades drainage to a commission of competent engineers.

That, of course, ought to have been done in the first place. No engineering work of such magnitude, complexity and uncertainty ought to be undertaken until the plans for it made by one engineer have been approved by a board of engineers of high standing.

Past mistakes cannot be remedied, but it is possible to cease throwing good money after bad. Enough has been made public in the congressional investigation to make clear the very precarious engineering foundation on which the present plans for draining the Everglades rest. The state authorities cannot proceed further with this work in the face of these criticisms. Either they must find a sound plan for carrying out the work which will produce the desired result, or if they can find no assurance that the work will be successful, it had better be abandoned.

Government Control of Water-Power

Elsewhere in this issue we give a summary of the report on water-power development in the United States, made by Herbert Knox Smith, Commissioner of Corporations. Mr. Smith emphasizes one fact upon which all engineers are in agreement—that everything possible should be done to hasten the development of water powers now unused to the end that the present drain on our fuel resources may be reduced.

The total developed water power in the United States at the present time is estimated at about 6,000,000 hp., but there is several times this amount of water power awaiting development.

The United States Geological Survey estimates the "minimum potential" water power of the country at 37,000,000 hp., and the "assumed maximum" at 66,500,000 hp., both figures being based on stream gagings and excluding possibilities from the extensive storage of water in large reservoirs so as to regulate the stream flow over considerable periods. When the possibilities of increased power by storage are taken into consideration, especially in connection with the fact that the bulk of the power demand continues for only a small part of the 24 hours, it becomes evident that the maximum possible water-power development in the United States must far exceed even the larger estimate above given.

These figures, however, relate only to ultimate possibilities. As the total stationary power in use is estimated at only 30,000,000 hp., it is evident that in many sections of the United States the real limitation to the development of water power is the possibility of finding a profitable market for it after development.

Second only to the public interest in promoting the substitution of water power for fuel power is the question of water-power control. That the business of generating and distributing hydro-electric power is almost everywhere a monopoly is pretty well known; and Commissioner Smith himself sets forth cogent reasons why it is advantageous to the public that the power stations supplying a large territory should be under one control.

Being a monopoly, however, it must be recognized by every unprejudiced student of the problem that some sort of government control is certain to be exercised in the future.

One way to effect this control—and it is this method which Commissioner Smith favors—is for the state or the federal government to retain control of the power site:

> The important fact which the Bureau desires to emphasize here is that the one point at which this right of the public can be exercised is in the resource itself, the power site, and not by any attempt to regulate the price of power. Thus, in the case of private operation of water-power privileges, the Government can charge a rental for that right commensurate with the natural advantages of the power site. Such rental, moreover, can be adjusted from time to time to insure the public increased compensation to correspond to any increase in the value of the power site which may arise from increased settlement of the country or other causes. In some cases, of course, a lease without rental charge might be desirable for a limited period,

in order to encourage development of inferior sites, which otherwise might not be utilized.

It is not intended to assert that exceptional conditions may not in some cases justify the outright sale of power sites. It is proper to point out, however, that the lease or rental system appears to present distinct advantages, particularly that of retaining in the public hands the ultimate control of the resource.

There is no denying the fact that the theory on which this plan of public control is based finds wide popular support, and if submitted to a popular referendum vote would be adopted by an overwhelming majority.

Water power as a gift of nature belongs in equity to the public at large, and while the public does not begrudge to the man or the corporation who develops that power a fair profit on the capital and industry which he employs, it does rebel against the proposal that he and his successors become thereby entitled to the sole right to use that power for all time, and privileged to charge the public for that power whatever they please.

One may disbelieve in and oppose such a theory, but he must recognize the broad fact that the public is not going to patiently endure uncontrolled monopoly in this field. Already public-service commissions have been established in many states, armed with laws which give them authority over corporations distributing electric current, by whatever power generated. It is well established that any such public utility today is subject to state control and regulation not only as to its service, but also as to the rates it may charge.

Mr. Smith, however, argues that regulation of the price at which current may be sold will still leave the holders of valuable water-power sites in possession of property which belongs in equity to the public. He says:

It is self-evident that the price which can be charged for water power cannot exceed the price at which fuel power can be sold. On the other hand, experience indicates that the price of water power will not be materially less than this fuel-power price. It might be less if the supply of water power were greater than the market could consume. This, however, rarely happens. Indeed, the Bureau's investigation indicates that the demand for power considerably exceeds that which can be economically produced from water in every considerable section of the country. Therefore, the owner of water power has no need, except for the purpose of temporarily effecting an entrance into a market, to reduce his price to a point substantially below the price of fuel power.

Under these conditions it would be impracticable to attempt to force by law the sale of water power at a price less than that of fuel power, since this would result in favoring those consumers who obtained water power at this lower price. The benefits of water power would thus merely be transferred from a group of water-power stockholders to a group of water-power buyers.

There are doubtless sites where water power can be developed so cheaply and sold in such a favorable market that the owners of the power are gaining profits so large that they ought to be divided with the public; but we believe such power sites are the rare exception. The majority of hydro-electric plants, we believe, have no easy task to compete with power developed from fuel and pay the expenses of operation, maintenance and fixed charges. Hydro-electric power must be generally sold at a lower price than steam power costs in order to compete with it, for with steam power the use of the steam for heating and other purposes in many industries makes the actual power cost extremely low. Further than this, the factory with its own power plant is independent of possible interruptions in supply of power due to power-station troubles, breaks in transmission lines, etc.

There are, of course, sections of the country where a profitable market awaits all the water power that can be developed; but with the rapid increase in possible radius of transmission and with the continued development of large powers, the water-power promoters in many districts are chiefly puzzled to know how to find customers for their power when developed.

Further than this, the cost of fuel power is rapidly being reduced by developments in steam machinery and gas and oil engines, so that the power monopoly is in a much less secure position than many of the other monopolies now under the muck rake. In view therefore of the increasing competition of fuel power and of the power of the state to regulate and control all public utilities the public need not lose much sleep over the water-power octopus.

There is, however, the practical question as to what should be done with the great water powers still undeveloped and under state or federal ownership. It is stated that nearly 14,000,000 hp. of undeveloped water power is still owned by the federal government. It is of first importance that this unused power should be developed as fast as the growth of population and demand warrants; but the public will not stand for any proposition to turn it over by either sale or perpetual lease to either speculative promoters or capitalists. Mr. Smith's plan for a leasing system on terms which shall be at once favorable to capital and protective of the public's property right in this gift of nature seems the best way out.

Of course, such a plan meets with strenuous opposition from those who hold that public property should in the future as in the past be turned over to the first private individual who should find it and lay claim to it; but the evidence is unmistakable that this way of getting rich quick is not much longer to be legalized by either the states or the nation.

The Effect of Water Vapor in Promoting Combustion

Most engineers are familiar with the claim that the presence of water vapor in a boiler furnace promotes complete combustion. The weight of opinion undoubtedly is that such claims cannot bear the test of scientific analysis. The generally accepted scientific theory is that a steam jet discharged into a boiler furnace reduces the furnace temperature by reason of the high specific heat of the steam compared with that of the gases produced by combustion, and that while the superheated steam may give up a large part of the heat which it acquires in the furnace before it leaves the boiler and passes into the stack, yet a certain percentage of heat will be carried off with the steam and therefore the net effect is to reduce furnace efficiency. On the other hand, notwithstanding the weight of scientific opinion just cited, there is considerable evidence indicating that in the case of certain fuels at least the presence of steam in moderate quantity in the furnace does tend to promote complete combustion and reduce the amount of loss from unburned gases passing up the stack.

An interesting side light upon the problem above recited is furnished by the practical experience of the builders of various oil engines, which use as fuel instead of gasoline some form of kerosene or distillates of heavier gravity than the standard gasoline. The manufacturers of this type of engine have found by experience that a small amount of water vapor introduced in the cylinder along with the oil is of material benefit in making the engine run more smoothly and especially in producing complete combustion of the oil and preventing smoky exhaust and carbon deposits in the cylinder.

Now why should the water vapor have this effect? It is understood, of course, that the presence of water vapor will reduce the maximum temperature and pressure reached at the moment of explosion and may then, by virtue of its high specific heat, give up part of the heat it has absorbed to raise the expansion line of the gases on the working stroke.

The presence of water vapor in the charge also reduces the temperature attained during the compression stroke and thereby enables a higher compression to be reached without danger of premature explosion of the charge. This statement, however, does not account for the observed fact that the presence of water vapor promotes perfect combustion in the cylinder, lessens the smoke discharge and the carbon deposits.

The first attempt to give a scientific explanation of the action of water vapor in promoting complete combustion that we have anywhere seen, we find in a paper

by James A. King, of Charles City, Ia., which was read at the recent annual meeting of the American Society of Agricultural Engineers.

Mr. King's paper was entitled "Low Gravity Fuels for Internal Combustion Tractors." As may be readily understood, one of the most important problems before agricultural machinery manufacturers is the production of engines for traction or other farm purposes, which will use ordinary kerosene instead of the expensive and dangerous gasoline used with most portable engines. Considerable success has been attained by several manufacturers in the production of engines of this type. As in the gasoline engine, a carburetor is used to furnish the explosive charge but the kerosene, instead of being vaporized, is introduced through an ator izer so that it enters the cylinder as a fine fog. As explained above, the use of a small percentage of water vapor with the kerosene had been found necessary to secure complete combustion. Mr. King offered in his paper above referred to the following explanation of the chemical action by which this result is produced:

Into the problem of burning the heavier oils there enters a chemical peculiarity inherent in the more complex hydrocarbons. They are subject to what is known as "cracking." At a given temperature any one of them with a molecular formula above a certain degree of complexity will break down into a simpler compound.

This temperature of cracking is below the temperature of ignition, and takes place without producing ignition. In this process of cracking a given molecule will break down into one or more molecules of the same series. Except in the naphthene or ethylene series this cracking results in the setting free of carbon.

Since the paraffin series predominates in most of the petroleum fields of the United States I shall confine this discussion to that series. The following equation will tend to illustrate what takes place when an oil "cracks":

(1) $C_{15}H_{33}$ + Heat = 2 C_7H_{16} + C.

As stated before, the temperature at which cracking takes place is lower than that of ignition. Consequently, this freed carbon immediately assumes a molecular state. This molecular carbon, unless prevented from doing so, is deposited as amorphous carbon and it is well known that amorphous carbon is decidedly inactive under normal conditions.

The above illustrated action will explain why it is that the ordinary gasoline engines will not successfully burn these lower gravity fuels for any considerable time without a serious carbonization of the working parts of the cylinder and piston.

In view of the facts set forth above and which are to follow, it is rather difficult to understand the credence given to the statement made after the close of the 1911 Winnipeg Motor Contest, that any engine will successfully burn kerosene and distillate simply by making a slight change in the carbureter by which the ingoing charge is heated so as to hasten the process of vaporization. They will burn it, yes. But to burn it successfully they must do it with the greatest possibly economy and efficiency. To do it with economy an engine must get maximum combustion with minimum expense or interference with the working of the engine. To do it with efficiency the engine must burn this fuel in such a way as to realize a maximum percentage of the heat of combustion as useful work. In either case the engine must continue to do this throughout its normal life, not for a few hours or days. And it cannot do this without providing some means of uniting this freed carbon with oxygen under conditions which shall render the resulting liberated heat available as work.

It was noted that when a charge of petroleum testing between 55° and 38° Baumé was ignited in the presence of a small quantity of water vapor, the combustion is much more rapid and complete than when the water is absent. Recognizing this fact, some manufacturers of kerosene-burning engines provide some system for spraying a small quantity of water into the cylinder coincident with the spraying of the fuel.

The following chemical equations seem to explain the reactions which take place from the time the charge is drawn into the cylinder until combustion has ceased:

(1) $C_{15}H_{32}$ + Heat = 2 C_7H_{16} + C.
(2) C_7H_{16} + 7 O_2 = 7 CO_2 + 16 H.
(3) 2 H_2O + Heat = 4 H + 2 O.
(4) C + O_2 = CO_2.
(5) 4 H + O_2 = 2 H_2O.

As stated above, reaction (1) takes place before ignition and is the process known as cracking. When the electric spark has ignited the charge a reaction such as (2) takes place. The heat generated by this is sufficient to run the temperature inside the cylinder of an engine working on normal load up to about 3000° F. This temperature is sufficient to dissociate water and so the hydrogen of (2) does not unite with oxygen when released by the carbon in favor of oxygen, but remains free. At the same time reaction (3) takes place because of the high temperature generated by (2).

Now free carbon and normal oxygen of the atmosphere unite only at very high temperatures, higher than those produced inside the cylinder of a working engine. But nascent oxygen is much more active, uniting at lower temperatures. So reaction (4) is coincident with (3). The nascent oxygen liberated by the dissociation of water in (3) unites immediately with the free carbon. Reaction (4) would liberate heat in compensation for that absorbed in (3), so that the pressure here would be maintained.

Due to the law of temperatures of gases under compression, as the piston moves outward the temperature of the gases within the cylinder decreases because of this expansion. At some point in the outward stroke the temperature falls below that of the dissociation of water. It is then, and not until then, that reaction (5) takes place. In this reaction the oxygen is that of the air and the hydrogen is that which was set free in reactions (2) and (3).

The above paragraphs and equations will tend to explain how the presence of the water vapor gives complete combustion when burning these heavier, more complex oils. This simple expedient of spraying the water thus gives a high fuel economy. At the same time it also gives a high efficiency. By preventing the carbonizing of the cylinders, pistons and valves it keeps the engine running freely without the fouling effect of carbonization. This is quite important. Carbonization wears and ruins the working parts rapidly. It also collects in cones and other protruding shapes which are apt to become incandescent and so cause preignition, with its attendant difficulties, losses and other evils.

It increases the efficiency of the engine and also of the fuel by its effect on interior temperatures. These more complex fuels always run an engine hotter than do the simpler fuels when pulling the same load. This difference in temperature seems to exist especially at the compression end of the cylinder. If an engine's cooling system is designed to let the engine work at the highest temperature consistent with efficiency when working on gasoline, it will, when burning the heavier fuels, soon become so hot that the piston will bind and even stick in the compression end of the cylinder if no water spray is used. But the use of water overcomes this difficulty. The dissociation of the water, as shown in reaction (2), absorbs a great amount of heat and so reduces the total temperature of the cylinder chamber. Of course, this heat is again given up in reaction (5). But when (5) takes place the temperature has dropped below that point where it interferes with the proper working of the engine. So that the action of the water is not to decrease the total amount of heat units liberated during the entire process of combustion, but to so distribute it throughout the entire volume of the cylinder that the cooling system can properly control it. In fact, the presence of the water increases the total amount of heat units liberated, because it makes possible reaction (4).

Mr. King in his paper above quoted distinctly stated that he offered the above as a working theory merely, and he did not claim to have made any tests or laboratory investigations to prove or disprove its correctness.

In response to a letter requesting further information as to the basis on which Mr. King has developed this theory, he writes us as follows:

The subject of utilizing low Baumé test fuels in internal-combustion engines of the Otto type seems to have but recently attracted seriously the attention of a very extensive public.

For the past three years the writer has been operating experimental farms for the Hart-Parr Co., on which our kerosene-burning engines instead of horses have been used as the general motive power in doing all kinds of field work. The fuel generally burned in these engines has been 38° Baumé test petroleum fuel, known as engine or Southwestern distillate, being scoured from oils from the Kansas and Oklahoma fields. This fuel has been used regularly in our power-house tests for several years.

In our work with these engines we start them with gasoline. They are run from one to five minutes on this fuel until the cylinders become warmed up. Then the gasoline is shut off and the kerosene or distillate tank connected with the carburetor by opening the valve in the fuel pipe. The engine is allowed to run on this low-gravity fuel without the use of water until the engine has begun to pound from overheating, which occurs in a very few minutes with this fuel. Then the regulating valve in the

water cup of the carburetor is opened gradually until this pounding ceases and the engine is still running well and powerfully.

Now come the observations which led me to make the assumption regarding the chemical action of the water and also regarding the inability of the free carbon to unite with the normal oxygen of the atmosphere. While the engine is working on the low-gravity fuel without the water spray, the exhaust gases are noticed to be a heavy black from the presence of free carbon. So long as the water spray is not used this heavy black exhaust will be seen. When the water-regulating valve has been opened the proper distance, this black exhaust disappears and the exhaust gases are as clean and colorless as when burning a good grade of gasoline. In fact, the operator knows he has his water-regulating valve opened the proper distance when he has succeeded in preventing this black exhaust without having drowned his fuel with too much water.

I have frequently opened the starting relief valves or the priming cups on these engines when they were operating on these heavier fuels without water and also when running with water. When operating without water the flame is of a red color and often fringed with black smoke. The red color of a hydrocarbon flame is known to be caused by the presence of incandescent particles of carbon. The blackness of the smoke or gas often seen fringing this flame would, of course, be due to the presence of nonincandescent particles of free carbon. When water was being used with these fuels, the flame shooting from these openings would be a blue color, sometimes verging to a light yellow. This color would denote the complete or almost complete absence of free carbon in any form.

In regard to the deposit of carbon within the cylinders, I would cite the following observation: One of our tractors under my control was run for over 200 days at heavy field duty, developing close to its maximum power continuously. At the end of this time compression was weakening and an examination was made for carbon deposits. Only a slight amount was found deposited in the first two piston-ring grooves, and this engine was worked always on these heavier gravity fuels.

These observed facts seem to me to prove the following things:

(1) Burning these fuels without the use of water spray produces a considerable quantity of free carbon which does not unite with the normal oxygen of the atmosphere under temperature conditions as they exist. A part of this is deposited within the cylinder and the rest is discharged with the exhaust gases.

(2) The use of the water spray results in the oxidation of this carbon under temperature conditions existing in the cylinder. This oxidation is so complete that no serious deposit within the cylinders was noted at the end of a year's constant use of an engine, and no free carbon is noted by the eye in the exhaust gases.

At the present time I am not in a position to authoritatively state that oxidation is produced by a chemical action of the water spray after the manner of my assumption in question. It may be that the action is more similar to that which takes place in the formation of water gas. It may also be that the water produces its effect by means of a catalytic rather than a chemical action. So far as I am familiar with the present sum total of the knowledge regarding the thermo-chemistry of hydrocarbons, to offer either one of these actions as an explanation of the method of oxidizing this free carbon is but to offer an assumed rather than a demonstrated explanation.

It seems to us that the matter presented by Mr. King is worth the careful attention of engineers and investigators interested in the development of internal-combustion engines, as well as of those interested in the problem of complete combustion of fuel of all sorts. It may be said that the combustion of oil fuel is so different from the combustion of coal that even if it were proved that the presence of water in the engine cylinder does not promote combustion, the same thing would not necessarily be true of combustion in a boiler furnace.

On the other hand, it is well understood that the gases given off from a bituminous coal with a high percentage of volatile matter contain as complex hydro-carbons as those contained in petroleum. It is quite within the possibilities that the presence of water vapor may act upon these gases in very much the same way that it acts upon the vapor produced from petroleum or its distillates in an engine cylinder. It is well to recall that the only thing which can burn is a gas, with the exception of carbon itself. All hydro-carbons, whether solid or liquid, must be reduced to the gaseous state before combustion occurs.

City Waste Studies in Ohio Cities

A voluminous report on the collection and disposal of garbage, dead animals, ashes, rubbish, stable manure, street and catch basin dirt and night soil in four large and five smaller cities of Ohio was completed in 1911 by engineers of the Ohio State Board of Health. Some of the data of most general interest are here given.

An investigation of the collection and disposal of all city wastes other than sewage in nine cities of Ohio was made in 1909 and 1910 in behalf of the State Board of Health. The cities studied were Cleveland, Cincinnati, Columbus and Dayton, four of the largest cities of the state, and Canton, Mansfield, Marion, Steubenville and Zanesville, among the smaller cities. The investigations included field studies, laboratory investigations and a large amount of time spent in digesting the information collected and preparing it for publication.

The report on these studies was transmitted to the board on July 21, 1911, by R. Winthroop Pratt, who was the chief engineer of the board. The field and laboratory work was done under the direction of Paul Hansen, acting chief engineer of the board in the absence of Mr. Pratt. Mr. Hansen having left the employ of the board before the report was written, the report was prepared by W. H. Dittoe, at that time assistant engineer and now chief engineer of the board. Mr. Dittoe conducted the field studies and A. H. Flower, as chemist, carried on the laboratory studies. In addition, two, and part of the time three, engineering assistants were employed. We are indebted to Mr. Dittoe for an advance copy of the report, which has been used in the preparation of this article.

A fourth of the report is composed of a general discussion of the information gathered, consisting of text and many tables and diagrams. The remainder presents data for the nine cities.

In all nine cities the collection and disposal of city wastes is under the general supervision of the department of public service. At Cincinnati, garbage is collected by contract, and at Canton, Mansfield, Marion and Steubenville wastes are collected privately, at the expense of the householders, but garbage disposal is at public expense.

Covered steel-tank wagon bodies are used for garbage collection at Cleveland, Columbus, Dayton and Zanesville. The Cleveland and Dayton tanks are detached from the running gear and shipped to the disposal works to be emptied. Two-platform wagons are used in five of the cities for the collection and transportation of garbage cans. These are characterized in the report as "somewhat less economical than the tank wagons, but entirely suited for small cities, where the quantities of garbage are not great."

For collecting ashes and rubbish, Cincinnati uses a back-dump wagon, Cleveland a bottom dump of standard make, and Dayton a modified slat-board wagon. None of the other cities studied have an organized collection system for ashes and rubbish.

All nine cities have a more or less efficient municipal street-cleaning service. The incomplete character of this service in the smaller cities led to confining the street-cleaning studies to Cincinnati, Cleveland and Columbus

TABLE I. SUMMARY OF ANALYSES OF GARBAGE OF FOUR OHIO CITIES, MADE BY OHIO STATE BOARD OF HEALTH IN 1909 AND 1910

	Cincinnati 10 Samples (a) Sept., 1909—June, 1910			Cleveland 28 Samples (b) May, 1909—June, 1910			Columbus 31 Samples (c) May, 1909—June, 1910			Dayton 30 Samples (d) May, 1909—June, 1910		
	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.
	Percentage			Percentage			Percentage			Percentage		
Moisture	76.6	79.3	74.5	75.6	78.9	72.7	76.4	79.7	73.2	80.6	83.3	78.2
Ash	3.66	4.80	3.01	3.21	4.02	2.63	3.30	4.61	2.43	2.57	3.39	1.96
Combustible matter	19.70	20.78	17.67	21.16	23.84	18.26	20.27	23.12	17.26	16.82	19.01	14.74
Calorific value, B.t.u.	2000	2215	1771	2057	2264	1808	1994	2289	1679	1712	1917	1488
Ether extract	4.02	5.46	3.22	3.85	4.54	2.89	3.96	5.12	3.03	3.83	4.76	2.98
Phosphoric acid, P_2O_5	0.29	0.36	0.17	0.24	0.34	0.18	0.22	0.32	0.09	0.19	0.29	0.15
Kjeldahl nitrogen	0.64	0.74	0.57	0.64	0.73	0.53	0.59	0.72	0.47	0.51	0.60	0.14
Potash, K_2O	0.28	0.34	0.21	0.30	0.35	0.25	0.25	0.32	0.18	0.20	0.29	0.13
	Results Calculated to Dry Basis											
Ash	15.65	20.35	12.71	13.12	15.06	10.90	13.98	17.66	10.56	13.19	16.15	11.50
Combustible matter	84.35	87.29	79.66	86.88	89.10	84.94	86.02	89.44	82.34	86.81	88.50	83.85
Calorific value, B.t.u.	8558	9186	8272	8459	8755	7883	8418	8839	8191	8776	8928	8179
Ether extract	17.15	22.64	14.52	15.85	20.72	12.53	16.74	19.06	14.53	19.77	24.41	16.15
Phosphoric acid, P_2O_5	1.26	1.91	0.71	0.99	1.38	0.65	0.95	1.63	0.41	1.00	1.42	0.72
Kjeldahl nitrogen	2.74	2.92	2.53	2.61	2.84	2.37	2.50	2.93	2.23	2.65	2.96	2.30
Potash K_2O	1.18	1.34	0.88	1.23	1.49	1.06	1.08	1.34	0.78	1.03	1.42	0.68

Notes: (a) Ten regular monthly samples. (b) Including four duplicate samples and twelve samples collected during two weeks' sampling, June 15–21, 1909, and Dec. 13–18, 1909. (c) Including eight duplicate samples and eleven samples collected during two weeks' sampling, June 1–5, 1909, and Nov. 29–Dec. 4, 1909. (d) Including seven duplicate samples and eleven samples collected during two weeks' sampling, July 12–19, 1909, and Jan. 10–15, 1910.

In units of 100,000 sq.ft., Cincinnati (in 1909) cleaned 126 units by flushers and machine sweepers and 195 units by hand; Cleveland (in 1909) cleaned 54 units by flushers less than one by machine sweepers and 319 by hand; Columbus, 18, 89 and 84, respectively. At Cincinnati, the flushing machines are supplemented by sweeping machines, but this is not the case in Cleveland and Columbus. Where flushing is used, the dirt is left in the gutters to drain "for a number of hours."

The average weight of garbage per cubic yard at the four larger cities in 1909-10 was as follows: Cincinnati, 1227 lb.; Cleveland, 1333; Columbus, 1173; Dayton, 1475 lb. The unit weights were greatest in August and September and least in the late winter and spring months, owing to differences in moisture.

Table I gives the results of laboratory analyses made from samples selected by the quartering method. The dry basis determinations are considered as better than the others for purposes of comparison. Attention is called to the "regularity in the average results and the similarity of the garbage from each of the cities." Differences may be explained by "improper sampling or unsuitable sampling days." Phosphoric-acid determinations are known to be too low, because large bones were thrown out, thus losing "upwards of 50% of the phosphoric acid."

TABLE II. AVERAGE COMPOSITION OF RUBBISH IN THREE OHIO CITIES, MAY, 1909, TO JUNE, 1910

	Cincinnati	Cleveland	Dayton
Number of loads	26	10	15
Paper (per cent.)	10.3	28.9	16.4
Rags	6.7	7.6	6.2
Wood	7.2	13.6	17.0
Tins	15.9	18.6	26.3
Iron	2.5	3.6	5.1
Other metal		1.1	1.3
Bottles: Weight	6.3	5.7	8.4
Number	28	38	56
Broken glass and crockery	11.0	14.2	12.7
Leather	2.4	2.3	3.0
Garbage: Bones	0.6	1.1	0.5
Other garbage	7.0	3.2	2.9

The composition of rubbish and ashes was studied with difficulty, because in no city in Ohio are these two classes of wastes collected separately. The rubbish made up only 18.5% by weight of the total in Cincinnati; 15.9% in Cleveland, and 9.3% in Dayton. Paper is collected separately at Cleveland.

At Cincinnati, 36 loads of mixed rubbish and ashes weighed an average of 786 lb.; at Cleveland 18 loads averaged 834 lb., and at Dayton 50 loads averaged 1090 lb.

The composition of rubbish alone in Cincinnati, Cleveland and Dayton is shown by Table II, and of ashes by Table III [the latter having been made up by us from several tables.—Ed.].

The per capita quantities of garbage collected in four of the cities in 1908 and 1909 averaged: Cincinnati, 181 and 193.4 lb.; Cleveland, 157.4 and 164.5 lb.; Columbus, 159 and 188 lb.; Dayton, 180 and 211 lb. The relatively low figures for Cleveland are attributed to the large percentage of foreign population and the activity of private collecting companies. The high percentage at Dayton is at least partly due to excessive moisture.

The per capita quantities of ashes and rubbish collected in Cincinnati and Cleveland in 1907, 1908 and 1909 and in Dayton in 1909, averaged as follows: Cincinnati, 0.64 cu.yd. or 517 lb. on basis of 787 lb. per cu.yd.; Cleveland, 0.36 cu.yd. or 298 lb. on basis of 834 lb. per cu.yd.; Dayton, 0.49 cu.yd. or 532 lb. on basis of 1090 lb. per cu.yd.

The final disposal of the various classes of wastes was effected as follows at the nine cities studied in 1910: Garbage by reduction at Cincinnati, Cleveland, Columbus and Dayton, and by incineration at Canton, Mansfield, Marion, Steubenville and Zanesville. Dead animals by reduction at the four cities having garbage-reduction plants and also at Canton; by incineration or burial elsewhere. Ashes, rubbish, street and catch-basin cleanings by dumping in all nine cities. Manure removed privately by farmers in all the cities. Night soil emptied into the sewers at Cincinnati, Cleveland and Columbus; buried at Canton, Mansfield and Marion; incinerated and burned at Marion; buried at Steubenville and Zanesville. It should be noted that these were the methods in use in 1910. From 1906 until into 1910, Columbus buried its garbage, night soil and dead animals on a 70-acre farm bought by it. The material was covered with 1 to 2 ft. of earth. The garbage was "converted to a stable condition and the land was ready to be used again" in about 2½ years. Fifteen acres per year were used for burial (population in April, 1910, 181,511). Properly done, disposal by burial is satisfactory if the haul is not so long as to make it too expensive.

The Cleveland and Columbus garbage reduction works are owned and operated by the cities [see Eng. News, Nov. 17, 1910, for description of Columbus plant and Nov. 30, 1911, for operating results of both plants.—Ed.] The Cincinnati and Dayton plants are privately owned. In 1911 a company was building a plant to treat the garbage of Toledo, thus bringing all Ohio cities of 100,000 population or over into the reduction class.

The general conclusions of the report as to the sanitary phases of garbage reduction works are as follows:

The reduction process or any modification of it will produce odors. The odors produced are objectionable to some persons, but are not more so than those produced by various industries engaged in manufacturing processes similar to garbage reduction. Such plants are, however, considered as legitimate and are not subject to the objection which is raised against a garbage plant. With

TABLE III. MECHANICAL ANALYSES OF HOUSEHOLD ASHES OF THREE OHIO CITIES, MAY, 1909, TO JUNE, 1910

	No. of analyses	Unburned coal	Clinkers and cinders	Fine material*	Moisture	Combustible matter Moist	Combustible matter Dry	Calorific value Moist	Calorific value Dry
Cincinnati	7	24.4	6.6	69.0	7.8	30.5	33.1	3087	3348
Cleveland	4	19.5	15.6	64.9	14.1	22.0	25.6	1815	2113
Dayton	7	21.1	12.7	66.2	19.3	21.5	26.6	2517	3119

*As separated by ½-in. screen.

proper design and careful operation, reduction plants may be conducted without producing a serious nuisance. The private plants which have been built in this country and which are made the basis for objection to the process, are as a rule built without regard for the prevention of odors and generally create a serious nuisance. The most recent development in this country is shown in the plant at Columbus, and it is there demonstrated that the reduction process may be carried on without the production of very serious odors. When a liquid waste is produced and discharged into a stream, the plant may create a decided nuisance. With the proper design, however, it is unnecessary to discharge an objectionable waste from the plant.

In like manner the general conclusions regarding the garbage furnaces studied may be given:

All of the garbage crematories in Ohio are patented types having certain distinctive features in design which differentiate them one from the other. They are common in one respect, however, in that the design provides for the burning of garbage alone, and to this end each type is designed for the use of fuel. Under ideal conditions it is likely that any of the furnaces in the state will give satisfactory results in the destruction of garbage. The proper operation of the plants, however, involves considerable study and attention on the part of the operator, and where this is not given, the furnaces do not produce entirely satisfactory results. The principal objection to the garbage crematory for the small city consists in the nuisance caused by the production of offensive odors in the burning process. These odors are avoided only under theoretical or ideal conditions when a high temperature is constantly maintained, and the failure even for a short period to maintain this temperature will immediately result in foul odors being emitted from the stack. The extent to which these odors are objectionable depends upon the location of the plant, and if this has been properly selected at a sufficient distance from the built-up portion of the community, no complaint is likely to be made.

The incineration process is entirely satisfactory from a sanitary standpoint, and no liquid or putrescible solid waste is produced. Its limitations for the burning of garbage alone are owing to the high cost of the process, and on an economic basis it is less desirable for the city of 100,000 population than a suitable reduction process. Where mixed collections are burned, the relative desirability of the incineration and reduction processes is not decided, and in some cases one and in some the other is most applicable.

Table IV shows the average yearly cost of garbage incineration at the four cities studied.

TABLE IV. COST OF GARBAGE INCINERATION IN FOUR OHIO CITIES

City	Year	Total net cost	Cost per capita	Cost per ton	Fuel Cost per capita
Canton.....	1906	$1508	$0.036	$1.97	$0.75
	1907	3671	0.083	4.30	0.83
	1908	2352	0.051	2.50	1.15
	1909	1999	0.042	1.78	0.97
Marion.....	1906	1729	0.110	2.66	1.81
	1907	1577	0.096	2.00	1.11
	1908	1809	0.107	2.59	1.10
Steubenville..	1908	1651	0.074	1.84	0.47
	1909	1330	0.062	1.11	0.28
	1910	2142	0.096	1.00	0.19
Zanesville...	1908	1150	0.068	....	....
	1909	1941	0.117	....	....
	1910	1676	0.110	2.58	0.63

Note: Character of refuse destroyed:
Canton, garbage, 100%.
Marion, garbage, 72%; night soil, 22.2%; dead animals, 5.4%.
Steubenville, garbage, 90%; mixed refuse and dead animals, 10%.
Zanesville, garbage, 75%; mixed refuse, 25%.

Causes of Boiler Explosions*

By S. F. Jeter†

The causes of steam-boiler explosions are so varied that it will only be possible to mention the more prominent ones in this paper. Broadly speaking, there is one explanation for all boiler explosions; namely, the boiler or some part of it is too weak to withstand the stress brought upon it. However, there are many causes contributing to such weakness.

The public and many engineers assume that most explosions are caused by some mysterious influence which cannot be foreseen or guarded against; but as an actual fact, a definite cause can be given for most explosions of considerable violence. That a large percentage of boiler explosions are from causes that might have been foreseen and prevented, is a well established fact.

The cause of boiler explosions which I will deal with first, because it is of particular interest to the manufacturer, is faulty design. Boilers are frequently constructed too weak for the pressure to be carried. This does not mean that the boiler will necessarily explode as soon as pressure is raised. Explosions from this cause usually occur after years of use, the overload on the parts having had time to gradually weaken them until they are no longer capable of resisting the excessive stress.

Of course, a manufacturer has practically no control over the steam pressure to be used on a boiler, after he has delivered it to the purchaser. However, if the manufacturer should stamp his name and the safe working pressure for which it was designed on each boiler built, it would act as a protection to his reputation in the event of excessive pressure being used. Proper inspection and fixing of pressures by experts is the logical remedy for explosions due to this cause.

Lack of properly flaring the tubes and nipples in water-tube boilers has frequently resulted in explosions. The Hartford Steam Boiler Inspection & Insurance Co. has always advocated proper flaring, and sometimes manufacturers have taken issue with the company on this point. Experience, which has cost the insurance company many thousands of dollars, has fully demonstrated the correctness of its position in this matter. The safety of the joint between a tube and plate when expanded and flared or merely expanded, is not a question of the relative strength of such connections newly made. When a connection of this kind becomes loose due to a movement of the parts from expansion or vibration, together with the excessive weight sometimes sustained, the tube or nipple with a flared end is decidedly more safe than one which is merely expanded. The flared nipple usually gives warning of its looseness by leakage before it pulls out.

A cause of explosions which is particularly reprehensible because of its being preventable is due to an owner's willingness to pit his judgment against more competent or conservative advice. Often boilers are known to be in need of repairs, but the work is put off to a more convenient season. A feed pump refuses to start, and instead of fires being drawn as soon as the water reaches the lowest safe level, a chance is taken that it can be run a little longer. Pressures are sometimes carried higher than reasonable safety would permit, to avoid the expense of larger engines, or better boilers. Boilers are forced beyond a reasonable duty for the heating surface they contain.

This last is a feature that must be reckoned with more in the future than it has been in the past. Many engineers are apparently trying to discover by experiment the limit to the rate of transfer of heat from fire to water through the medium of boiler tubes and plate. In order to show minimum investments necessary and other economies resulting from high rates of driving, engineers are prone to advise overloads on both engines and boilers, and all seem to overlook the all-important question, "Is it safe?"

Boiler explosions also result from neglect or carelessness in operation. Scale and deposit are often allowed to collect in quantities that are dangerous. Connections to water columns are permitted to become stopped. Oil is permitted to enter the boiler with the feed water. Repairs to settings which may affect the safety of the boiler are neglected. Safety valves are not regularly tested to ascertain if they are in operating condition.

Occasionally a boiler owner who discovers his safety valve leaking, with an eye blind to every consideration except the prevention of loss of steam, places a stop valve on the connection to the safety valve or plugs the outlet. A steam gage registers incorrectly and the engineer screws down on the safety valve in an endeavor to make the gage show the correct pressure. Again, the pressure of steam is not sufficient to produce results desired with the machinery using it, and

*Abstract from a paper presented before the American Boiler Manufacturers' Association at the annual meeting in March, 1912.

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the safety valve is deliberately made inoperative to overcome the difficulty. All of these conditions have been the cause of boiler explosions in the past and they probably will continue to contribute their share in the future until the steam user is more thoroughly educated in the matter of the risk he runs by such carelessness.

Tube Failures

Tube failures, which are chiefly confined to the water-tube type of boiler, are a source of grave concern to the boiler-insurance interests on account of the difficulty of guarding against the usual failure of this kind by inspection. A defective weld usually does not show on the surface of the tube, and even where the surface indications would lead to suspicion, a large percentage of the tubes in water-tube boilers are beyond the reach or vision of the inspector. The thorough inspection of tubes before they are placed in the boiler, while very unsatisfactory even taken in connection with the mill test, is about the only protection possible against accidents due to defective tubes.

The seamless tube, of course, will prevent accidents due to defective welding, but tubes made by this process are not always of uniform thickness, and with the cold-drawn product there are apparently internal strains produced by the process of manufacture which sometimes cause the tubes to break when merely heated. If cold-drawn tubes are used for boiler purposes, the annealed stock should be obtained. Hot-drawn seamless tubes are meeting with considerable favor among engineers for boiler purposes.

A considerable percentage of tube failures occur without the slightest evidence as to their cause. A welded tube frequently breaks through the solid metal away from the weld, without being corroded or weakened in any way that may be detected by the eye, and without evidences of overheating.

It is a fact that while pressures and rates of driving have been remarkably increased during the past 15 or 20 years, no increase in the thickness or strength of tubes has occurred. That the thicker tube is safer seems to have been demonstrated by a number of cases where heavy tubes have been put in place of those of standard gage at the recommendation of the Hartford company, and tube troubles have ceased.

Of course it can be contended that the theoretical factor of safety is higher on tubes even of standard thickness than on almost any other portion of the boiler. However, under operating conditions accompanying high rates of driving, is it not possible that there are decided fluctuations in the temperature of the material in the tubes? The rapid formation of steam bubbles removes for a certain interval of time the water protection from the inner surface of a tube, and the thinner the material, the higher will its temperature rise during a given time in which it is not protected. It is conceivable that the structure of the metal in a thin tube may be affected in time by this constant change in temperature until it gives out, while the thicker tube might not be affected to the same degree.

The importance of the question of tube failures to the operator of boilers as well as to the insurance interests can be appreciated when I say, as I believe I can conservatively, that the toll of loss of life and limb exacted by such failures probably exceeds other classes of boiler accidents when the relative number of fire-tube and water-tube boilers in use is considered.

It is, of course, readily recognized that with every precaution which can be taken boiler explosions cannot be entirely eliminated, but their number may be lessened materially. A proper inquiry into all accidents of this kind by government officials qualified and clothed with ample authority to get at all facts in each case, and place the blame, if any, where it properly belongs would tend to reduce the number of explosions materially. This is a feature we might profitably copy from our English cousins.

The Annual Convention of the American Railway Engineering Association

The 13th annual convention of this association was held at the Congress Hotel, Chicago, on Mar. 19 to 21, with a large attendance and the usual display of active interest in the proceedings of the meeting. There were five business sessions, and the annual banquet was an elaborate and well attended entertainment. The officers for 1912 are as follows: President, Charles S. Churchill, Chief Engineer, Norfolk & Western Ry.; Vice-Presidents, Edwin F. Wendt, Assistant Engineer, Pittsburg & Lake Erie R.R., and W. B. Storey, Jr., Vice-President, Atchison, Topeka & Santa Fe Ry.; Treasurer, Geo. H. Bremner, Engineer of Illinois District, Chicago, Burlington & Quincy R.R.; Secretary, E. H. Fritch, 962 Monadnock Block, Chicago.

Business Affairs of the Association

The association has been noted for its energetic work, and the President, W. C. Cushing (Pennsylvania Lines), in his annual address called attention to certain conditions which have been brought about by this energy. The principle of the association is to have certain subjects investigated and reported upon by a number of standing committees, and so enthusiastic have been these committees that the cost of printing the ever increasing amount of matter presented by them has at last begun to trench upon the surplus which has been accumulated in previous years.

For the meeting of 1911, the bulletins containing the reports and their appendices aggregated over 1200 pages, and represents a climax in the affairs. Suggestions were made that not more than two subjects should be assigned to each committee, but this was not followed, although in some cases the number of subjects was reduced. The committees were notified, however, of the conditions, and requested to limit or concentrate their activities.

The result, as shown at the 1912 meeting, is encouraging. The reports, etc., aggregate about 450 pages, and there is an absence of the reprinted matter which has, in some cases, supplemented the reports to the extent of overloading. On the other hand, the interest in the work has not slackened, and the character of the reports presented is fully up to the former standard. In other words, the reduction has been in quantity and not in quality.

Under the financial conditions noted above, it has been necessary to introduce some economies in the management and to seek for increased revenue. One means of economy has been to print the reports in sufficient number to serve for the *Proceedings* as well as for the advance copies. This will necessitate arranging the *Proceedings* with all the reports grouped together, and following them by the discussions, but this slight inconvenience is well warranted by the material saving in cost of press work and printing. Other economies are effected by reducing the number of bulletins issued during the year, and by obviating second-class rates on the association's publications. As a temporary expedient for increasing revenue, it is intended to secure additional advertisements for the publications, but the president stated explicitly that this is only an emergency measure. The Board of Directors is opposed to the principle of deriving revenue in this way, and it is hoped that eventually the insertion of advertisements can be abandoned entirely.

Some of the investigational work of the association is of a specially important character, bearing directly upon the economy, efficiency and safety of railway operation. This is specially true of the work of the Committee on Rails, and it is worthy of note that to assist in the experiments and other work in connection with the study of the rail problem, the American Railway Association contributed $6200 in 1910 and $10,000 in 1911; this is strong proof of the recognition by the railway companies of the value of the work of the Railway Engineering Association.

Following this statement of the business affairs, the president's address reviewed some of the notable engineering achievements of the past year. In con-

clusion he quoted from ENGINEERING NEWS (Feb. 17, 1910), "The True Character of a Complete Engineer," as set forth in a book published in 1645, and he expressed the opinion that many engineers of today measure up to "the complete engineer" of nearly 300 years ago.

The report of the secretary (E. H. Fritch) showed a total membership of 1050 for the date of Mar. 15, 1912; this is a net increase of 63 since the last meeting. Of this number, 899 are in the United States, 83 in Canada, 21 in Mexico and Central and South America, 2 in Europe, 5 in Australia, and 20 in Asiatic countries. The report of the treasurer (Geo. H. Bremner) showed the following: Balance of March, 1911, $13,216; receipts, $24,255; expenditures, $29,370; balance of March, 1912, $14,329.

REPORTS AND DISCUSSIONS

As noted above, the quantity of material presented was less than in former years, but the quality was up to the standard. Owing to this reduction in quantity and to the fact that some committees reported matter for information only (and not calling for action), the discussions were more limited than usual, with the result that only five sessions were required to dispose of the business. There were brisk discussions of several subjects, however, although there were no very serious problems submitted, such as have brought forth sharp controversial discussions at some former meetings. The reports being shorter than usual, the subjects for discussion were fewer in number, so that there was more concentration of discussion than has been the case at some other meetings. As the association published in 1911 the latest edition of its "Manual of Recommended Practice," there was no discussion as to matter to be included in this "Manual," while at the meeting of 1911 a good part of the discussions related to this subject. Every one of the 19 standing committees and the two special committees made a report, and all the reports were printed in advance of the meeting. We give below a brief review of the reports and discussions, and abstracts of some of these reports we shall publish separately.

RAILS

The committee has continued its research work, which is under the direction of Mr. Wickhorst. This includes two investigations as to the relation of size of ingot to the quality of the steel in the ingot and the rails, and a third to determine the influence of the temperature of rolling upon the properties of the rails. This last indicated that the temperature had little influence upon the ductility and deflection in the drop test, and that its influence showed most prominently in the tension test; the reduction of area decreased as the temperature of rolling increased, and the size of grain increased with the increase in temperature. The committee submitted also tentative specifications for rails; these were read and approved. They include provision for a drop test continued to destruction, and a minimum permanent set after one blow under this test. In the chemical requirements the maximum silicon is 0.2% in all cases, and phosphorus 0.1% for bessemer and 0.04% for open-hearth steel; the other requirements are as follows:

	Rails Lb. per yd	Carbon P. ct.	Manganese P. ct.
Bessemer	70 to 85	0.40 to 0.50	0.80 to 1.10
Bessemer	85 to 100	0.45 to 0.55	0.80 to 1.10
O-Hearth	70 to 85	0.53 to 0.66	0.60 to 0.90
O-Hearth	85 to 100	0.63 to 0.76	0.60 to 0.90

An appendix to the report contained a review of the history of rail design and manufacture prepared for (and by request of) the Indiana Railway Commission.

The discussion on this report was opened by a lengthy statement from Mr. Howard (U. S. Bureau of Standards), who had been invited to attend. His views were somewhat opposed to those of the committee in regard to the value of the drop test. On the other hand, Mr. Fritch (Chicago Great Western Ry.) advocated a further development of this test, to apply to every ingot. This suggestion will be considered by the committee, although it was pointed out that it is hardly practicable at the present time, as it would involve too much delay and interference with the operation of the mills.

TRACK

SWITCHES AND FROGS—The principal feature of this report was its general specifications for frogs, crossings and switches; these were adopted. The committee recommended four lengths of switch rails for turnouts of different classes, as follows: 33 ft. for turnouts in which the divergent route is operated at high speed and for frogs over No. 14; 22 ft. for main-line turnouts and crossovers in which the divergent route is operated at low speed, and for frogs of No. 10 to No. 14; 16½ ft. for yards, and where frogs of Nos. 6 to 10 are used; 11 ft. for turnouts requiring frogs of large angle (No. 6 and under).

The committee recommended also the adoption of frogs Nos. 8, 11 and 16 as meeting all requirements for yards, main-track switches and junctions; and advocated the gradual elimination of frogs of other numbers. It was noted that the tables of track details published in ENGINEERING NEWS in 1908 show that 55% of the roads used No. 10 frogs and only 5% used No. 16, but the latter included some very important roads. No. 7 frogs are rapidly disappearing, being replaced by No. 8; and No. 10 frogs are giving place to those of higher numbers.

After some discussion the recommendations both as to switch rails and frogs were adopted. Mr. Bremner (C., B. & Q. Ry.) referred to the use by German railways of very long switch rails which are curved, are of special section, and have a fixed heel. He thought the tendency in this country is to increase the length, and that if the German design could be adapted to American practice (and used with switch rails of hard steel) it would be an important improvement worth introducing. As to the frogs, the discussion turned largely on the question whether the numbers advocated are the best, but it was shown that the main point is to replace the present great variety of frogs with three designs (or frog numbers) which will meet the requirements for the three classes of turnouts mentioned in the report.

TIES

SIZE OF TIES—An investigation of figures presented in 1906 showed that for 139,000 miles of track 47.3% had ties 6x8 in. x 8 ft.; 10.3% had 7x9 in. x 8½ ft.; and 10% had 7x8 in. x 8 ft. Also that 42.7% had 16 ties per 30-ft. rail, 18.7% had 18 ties, and 13.8% had 17 ties. The inquiry made in 1911 indicates an increase in number, since out of 40 railways, 50% recommend that 40 to 45% length of rails should be supported on ties, while 10% recommended 30 to 40%. There is great inconsistency of opinion as to size, but there is a sentiment in favor of a larger size and the committee favors the recommendation of the late A. M. Wellington for a tie 7 in. thick, 7 to 9 in. wide and 8½ ft. long. It is not practicable to lay down any fixed rule as to size or spacing, but as to the latter, for main lines it is good practice to space ties 10 to 12 in. between faces; the width is not so important if this spacing is followed, but the minimum of width should be 7 in.

This portion of the report was referred back to the committee, on the ground that the subject should be studied from the theoretical point of view instead of basing the recommendations on a review of individual practice. The president (Mr. Cushing) explained that the Board of Direction had intended the committee to undertake such study (as has been done already in Europe), but that the committee evidently misunderstood its instructions.

TIE RENEWALS—As to the practice of renewing ties in continuous stretches or by single ties, the returns show a practically unanimous opinion in favor of the latter, and this is recommended by the committee. This has reference only to untreated ties, however, no mention being made of treated ties, which should have a more uniform life.

Mr. McDonald (N., C. & St. L. Ry.) took issue with the committee; he thought the present system of renewal (by single ties) is largely a matter of habit and custom. The continuous system could be

substituted with advantage, with a saving in ties and in maintenance work. This system has been used as an experiment on his road (with untreated oak ties), with satisfactory results. Mr. Meade (A., T. & S. F. Ry.) said he had used the continuous-renewal system with creosoted pine ties, and with good results.

METAL AND CONCRETE TIES—The report presents information supplementing earlier reports as to experience on different roads in this country, but there is little of importance. With the exception of the Buhrer (or Carnegie) H-beam steel tie (which is used extensively for both open track and switches), the ties are experimental and used to a limited extent only. Some roads have removed these Buhrer ties on account of troubles with insulation. The fastenings also are not generally satisfactory. The committee presents the following conclusions, the first of which was adopted:

"1. The concrete tie, combination concrete and metal tie, or combination asphalt and metal tie has not proved a success; due to, A, fracture caused by vibration; B, excessive weight and consequent difficulty in handling; C, deterioration of asphalt filling. 2. A combination tie of steel and wood gives promise of developing an economic substitute for wood. 3. The steel tie has proved a satisfactory substitute under heavy medium-speed traffic; it is durable, line and surface can be maintained, it has sufficient resilience and can be insulated. The fastenings can and no doubt will be improved."

Wood Preservatien

GROUPING OF TIMBERS—This committee recommended that ties should be grouped for treatment: (1) Those of the two general species of hardwoods and pines should be grouped separately; (2) heartwood and sapwood pine ties should be kept separate; (3) green and seasoned ties should be kept separate, and (4) ties of approximately the same period of seasoning should be put together for treatment. These recommendations were adopted.

SPECIFICATIONS FOR CREOSOTE OIL—The revised standard specifications provide that the oil shall be "the best obtainable grade of coal-tar creosote; a pure product obtained from coal-gas tar or coke-oven tar, and free from any tar (including coal-gas tar or coke-oven tar), oil or residue obtained from petroleum or any other source." At 38° C., it must be liquid and of at least 1.03 specific gravity; it must give no distillate below 200° C., not over 5% below 210°, not over 25% below 235°, and the residue above 355° C. (if over 5% in quantity) must be soft. The oil must not contain over 3% water. Specifications were submitted also for oil of lower grades; these are the same as above, except that the distillate below 210° and 235° may be 8 and 35% for No. 2 oil and 10 and 40% for No. 3 oil, while the specific gravity for the No. 3 is 1.025.

Signs, Fences and Crossings

FENCING—The main work of the committee has been in regard to wire fencing. It finds that of 44 railways (61,000 miles), 28 use woven wire exclusively, 6 use barb wire exclusively, 2 use ribbon wire exclusively, and 5 use both barb and woven wire. As to corrosion, wire galvanized after weaving has proved most durable and efficient, but at present only certain forms of weaving appear to be adapted to this process. As to fence posts, the prevailing costs are 12 to 15c. for wood and 18 to 22c. for concrete, while the costs range as high as 40c. in both cases; the difference in cost, therefore, is not so great as to be prohibitive of concrete. Metal posts costing 23c. are claimed by the maker to have a life of 30 years.

STREET CROSSINGS—In the usual construction a rail (laid on its side) or a plank is laid against the track rail to form the flangeway, and the space between these is filled with planks or brick paving. In several cases a 141-lb. girder rail is employed. Three roads are considering a special form of rolled flangeway filler with extension beyond the rail head (similar to street-railway construction), and arrangements are being made to place a trial order with a steel company.

The committee is investigating the matter of securing uniform designs for substantial and economic signs for railway purposes, and the chairman, Mr. Stein (C. R.R. of N. J.) emphasized this as an important matter. The report was accepted as information and without discussion.

Roadway

This was another report submitted as information and accepted without discussion. It dealt with two subjects:

ROADBED PRESSURES—Some general information was presented in regard to unit pressures allowable on roadbed materials, and the report advocated the appointment of a special committee (with appropriation) representing the roadway, ballast and track committees. Its special purpose would be (1) to make experiments to determine the magnitude and distribution of the load transmitted to the roadbed through ballast of different kinds, and (2) to determine by test the bearing power of various materials under varying conditions ordinarily found in the construction of the roadway.

TUNNEL VENTILATION—The report stated that artificial ventilation is usually unnecessary in this country, and that when necessary the most efficient method probably is to force air in at one end by fans powerful enough to drive the smoke ahead of the train. A table gave particulars of nine tunnels ventilated by this method according to plans of C. S. Churchill and C. C. Wentworth.

There was some discussion as to whether it was advisable to have specifications for these lower grades of oil. On one hand, it was argued that to do so would impair the standard specifications. On the other hand, it was pointed out that the treatment with oil is only a means to an end, and as some treated ties would fail by wear before they are affected by decay it would be false economy to require the more expensive treatment with the high-grade oil. This latter view prevailed and the specifications were adopted.

Ballast

The report included the following (1) a review of the use of gravel ballast, with a table of the proportions of various gravels on different railways, and description of a ballast-washing plant; (2) tests of stone for ballast, with a table of the results of government tests of stone used for ballast on various roads; (3) the depth of ballast. As to this last matter the following conclusions was presented and adopted:

"With ties 7 in. x 9 in. x 8½ ft., spaced 24 to 25.5 in. centers, (1) a depth of 24 in. of stone ballast is necessary to produce uniform pressure on the subgrade, and (2) a combination of a lower layer of cinder ballast (18 to 14 in.) and an upper layer of stone ballast (6 to 10 in.) aggregating 24 in. deep, will produce nearly the same results."

The report recommended that the physical tests already adopted for stone for ballast should be supplemented by the compression test used by the Road Bureau of the U. S. Department of Agriculture to determine the suitability of stone for road construction. This was adopted, but Mr. Churchill (N. & W. Ry.) instanced a simpler chisel test used on his road for the same purpose.

Yards and Terminals

This report was brief, and dealt mainly with a typical plan for a division engine terminal, with ashpit and roundhouse, and facilities for supplying coal, water and sand. There was also a list of published articles on the mechanical handling of freight and baggage. The report was adopted practically without discussion.

Signals and Interlocking

The committee submitted some minor changes in specifications for insulation, and these were adopted. On the subject of a comprehensive and uniform signal system there is again in this committee the division of opinion between those who favor a large and a small number of indications to be given to the enginemen by means of the signals. It needs to be fully recognized that signaling is only a means to an end, and this end or purpose is to

insure safety and efficiency in the operation of trains. From this point of view it seems that the minority report has the stronger argument when it argues in favor of the smaller number of indications.

The minority report presents five indications, of which the two last are supplemental: 1, stop; 2, proceed with caution; 3, proceed; 4, proceed at low speed; 5, proceed at medium speed. The majority report presents such additional indications as "proceed, prepare to stop at next signal," or "proceed, prepare to pass next signal at medium speed." These are objected to by the minority on the principle that each signal should give its own indication only, and not one in relation to the next signal ahead; also that even high-speed service does not necessitate such addjtional indications.

However, there was no discussion, as the report was submitted only as information. This was due to the fact that at the meeting of the Railway Signal Association, on Mar. 18, a similar report was presented and rejected. The disposition of the subject therefore remains in abeyance.

Water Service

CONCRETE TANKS AND SUPPORTS—The advantages and disadvantages of reinforced-concrete tanks (and towers) and standpipes are outlined and discussed, and on the whole the committee sees no reason why railways engaged in permanent reconstructions for fixed water supplies should not consider favorably a beginning in the use of reinforced-concrete tanks. Specifications were submitted (as information only) for concrete standpipes, with general plans for both standpipes and elevated tanks. Revised specifications for steel tanks were submitted also, and were adopted.

TREATED WATER AND BOILER CORROSION—The report presents a paper prepared for the committee by J. F. Francis describing a serious case of pitting and corrosion in a locomotive boiler using water treated by a softening process. The trouble arose from the use of hard (untreated) water at stations where no softening plant was installed, but until this was determined it led to the softening process being regarded with some suspicion. The remedy was to maintain the water in the boiler slightly caustic and to control the causticity by continuous chemical examination of samples drawn from the boiler.

Masonry

SPECIFICATIONS FOR CEMENT — This committee was represented in the general conference held by a government board appointed to prepare a standard specification for portland cement for the use of all government departments and its report reviews the proceedings of the conference. The principal differences of opinion were: (1) the use of the Vicat needle or the Gilmore needle in determining time of set, and (2) the Vicat needle or the ball test for determining normal consistency. The government board adopted the Gilmore needle and the ball test.

CONCRETE—Three subjects relative to concrete work were investigated, and as to each of these the report presents a mass of information as to individual practice and experience, accompanied by general conclusions as to the second and third subjects. Some part of this matter we shall publish later. The three subjects are as follows: (1) waterproofing, (2) patching and repairing, (3) depositing under water. As to the third subject, a concrete mixture of 1:2:4 was recommended, and also the use of the tremie or the drop-bottom bucket. As the conclusions seemed to apply only to work done within cofferdams, Mr. Tratman (ENGINEERING NEWS) suggested a modification by which they will apply to work done in open water (as in pier and harbor work). All the conclusions were adopted.

Iron and Steel Structures

This committee submitted specifications for the erection of steel railway bridges, and these were adopted after somewhat extended discussion. The committee submitted also a progress report on the tests of secondary stresses which are being made on a number of bridges. The latter matter we shall deal with in another issue.

Wooden Bridges and Trestles

The report was submitted as information only, and was adopted without discussion. It included reference to different subjects.

PILING—A proposed experimental investigation of sheet piling had not been carried out, but the plan as outlined is to use a concrete box divided by a vertical spring-steel diaphragm (secured at top and bottom). The box will be filled with sand and one side then excavated, so that the diaphragm will represent the sheeted side of a trench in sand, and the curvature of the plate will be noted. The pressure required to give this deflection would then be determined. As to pile-driving formulas, it seems that few roads keep records of pile driving. But there are so many modifying conditions that formulas must be empirical, and as these conditions can best be noted from actual experience, it is very desirable that records should be kept of the behavior of piles during driving and after loading. Such record is specially valuable in the case of test piles loaded to failure.

BRIDGE FLOORS—When fire protection is provided, this is generally by (1) a full ballasted deck, (2) a thin covering of ballast, etc., on the floor, or (3) a sheet-metal covering. An inquiry had been made as to inside guard rails; these are of two classes: A, two rails, with their ends brought together at the middle of the track (beyond the bridge); B, three rails straight throughout their length, with their ends bent vertically so as to be below the base of the track rails.

Buildings

The report consisted mainly of information in regard to various roof coverings (supplementing the report of 1911), and several drawings showing (1) different styles of flashing used for roofs and walls, and (2) methods of laying asbestos shingles. It was accepted as information, without discussion.

Grading of Lumber

The committee submitted definitions of defects and rules for the grading of lumber, which represent specifications for maintenance-of-way lumber, as it can be purchased in the market at the present time. Similar matter was presented at the last meeting (1911) but was not then adopted. The report was adopted without discussion.

Electricity

The committee submitted a diagram of clearance lines for railways using third-rail conductors. These were adopted, as was a recommendation that the third-rail gage should be measured from the gage side of the running rail to the gage side of the third rail instead of to the center of the latter. This part of the report was supplemented by over 30 diagrams showing the clearance lines of different railways.

In addition to this, the committee submitted specifications for electric-light and power lines crossing above railway tracks and wires. They are practically identical with those adopted by a joint commission of electrical associations, and were adopted. They provide, however, for voltages only up to 70,000, but it was shown in the discussion that some railways are crossed by lines carrying 100,000 and 110,000 volts.

Rules and Organization

This committee submitted additional instructions to employees of the maintenance-of-way department in regard to such track work as ballasting, tie renewals and rail renewals. These supplement general rules previously adopted. The rules were adopted, after being discussed at some length, and several modifications for the improvement of wording and style were suggested by Mr. Tratman (ENGINEERING NEWS). Mr. Baldwin (Ill. Cen. R.R.) objected to the rule for straightening rails kinked in service; he thought such rails should be considered as second class, but the rule was adopted. A rule requiring ties to be laid heart side down was changed to read that they should be laid to obtain the best bearing.

RECORDS AND ACCOUNTS

RAILWAY STOREKEEPING—The committee had been instructed to study the economical management of a storehouse so as to assure a minimum stock of materials. It studied the question from the railway point of view rather than the narrower storekeeping point of view, recognizing that this is only one feature of railway service. This report was adopted without discussion and presented the conclusion that the object of a storehouse is to provide materials and tools when required, so that the cost of work may be a minimum, bearing in mind the factors of delay to work or labor and of interest on investment in stock. Matters for consideration are standardization, organization, distribution, classification and stock accounts. As to the economic side of the question of minimum stock, the report states as follows:

"Assuming that it is possible to reduce the stock on hand 50%, the saving per annum would be only 1.1% of the amount paid annually in wages to the employees (to whom the stock is supplied), so that even a slight loss in their efficiency through failure to secure materials and tools as required, will soon absorb much more than the amount saved by reduced investment in stock. Therefore, the most important function of a storehouse is the prompt delivery of materials and tools so that delays to labor resulting from their lack may be reduced to a minimum."

UNIFORM GENERAL CONTRACT FORMS

This committee submitted a general form for construction contracts, including the agreement. The latter is a double-leaf sheet or folder, having the introductory statement on one page and the space for signatures on the other. This alone may be used for small or unimportant contracts, but for larger work the contract form may be inclosed, still leaving the agreement at the beginning and the signatures at the end. Specifications also may be either inclosed or attached. The form is not complete, but the clauses submitted were discussed and approved.

ECONOMICS OF RAILWAY LOCATION

A brief progress report outlined the work of the committee in analyzing railway operating costs. It was accepted without discussion.

CONSERVATION OF NATURAL RESOURCES

The committee's report deals with tree planting and general reforestation as related to the railways of the country. Attention is drawn to the enormous consumption and waste and the loss by fire, and it is shown that experience abroad proves that damage by forest fires is preventable. The consumption of timber in this country (not including fire losses) is 230 cu.ft. per capita, as against 37 cu.ft. in Germany and 25 cu.ft. in France. Appended to the report were abstracts of numerous published articles relating to the resources of coal and fuel oil.

EXHIBITS OF RAILWAY APPLIANCES

The annual exhibition of railway material and supplies, held in connection with the convention of this association, is to railway engineering and maintenance-of-way what the exhibition at the annual meetings of the Master Mechanics and Master Car Builders' Associations are to railway motive power and equipment. It was larger than usual this year, and was so much in excess of the large capacity of the Coliseum that it was necessary to engage also the First Regiment Armory, which is an adjacent building, so that communication could be provided between the two buildings. Even then, several applications for space had to be rejected. Many of the exhibits were standard materials or modifications thereof, but there were novelties and new ideas in plenty. As the Railway Signal Association held a meeting during the same week, and as this works in close relation to the Railway Engineering Association, the sagnal-manufacturing companies had extensive exhibits, including equipment for electric railways as well as for steam railways. The exhibition is managed by the Railway Appliances Association; President, A. P. Van Schaick (Lackawanna Steel Co.).

Independent of this special and temporary exhibition there was the new "Permanent Manufacturers Exhibit of Railway Supplies and Equipment," which was opened during the week of the convention. This is located on two floors of the large Karpen Building, 900 S. Michigan Ave., and is intended for the convenience of manufacturers of railway material and supplies in showing their material to purchasers and railway officers. This permanent exhibition has been noted before in our columns.

A Machine for Cutting Granite Cubes for Paving

Many miles of pavement surfaced with granite cubes are in use in Europe, notably in Germany, Hungary, Austria and England. The cubical blocks, under the name of *kleinpflaster* in Germany and "Durax" armoring in England, are used sometimes as a surface for old macadam roads and sometimes for new pavement. In the latter case, the stone cubes are bedded in a thin layer of sand over a concrete foundation 6 in. or more in thickness. The cubes range from 2½ to 4 in., the ordinary size being from 3 to 4 in.

They are placed in concentric rings in the plane of the pavement or in diagonal rows. After the stones are in position, they are rammed until firmly bedded on the foundation, when there should be not more than about ¼ in. of sand under the shallowest stone. Before and during this process the road surface is freely watered and the spaces between the blocks is well filled with sharp river sand. When complete the whole surface is covered with sand to a depth of ¾ in., which is expected to gradually work into the joints. It is claimed that this gives a pavement which resists the scouring action of water and is sufficiently elastic. Another method of laying the "Durax" armoring in England is to set the granite cubes in a foundation of bituminous concrete, grouting the joints with a similar material.

In some respects this gives an ideal pavement. The stone blocks are light in weight and easy to handle, and yet are thick enough to give an adequate wearing surface. Due to the comparatively small depth of the blocks the pitch used for grouting can penetrate through the surface of the pavement and into the sand below. Another advantage which the small cubical blocks have over large granite blocks is that there is less tendency to tip or rock; and since they can be laid with much closer joints, there is less tendency to wear down along the edges.

It is essential, however, that the cubes be cut with considerable accuracy in order that the pavement may be laid with a smooth surface and with close joints. The width of joints must be kept down to ¼ in. to obtain the best results in wear and smoothness. If the stones are cut by hand the pavement is very expensive. For this reason, there has been some experimenting with artificial stone and with concrete. An article describing experience with experimental roads paved with concrete cubes in New York State was published in ENGINEERING NEWS, Feb. 2, 1911, p. 128.

A machine for cutting the granite cubes has been developed in Europe, which it is claimed gives very satisfactory results both in cost of production and in the quality of the product. A photograph of one of these machines is shown in the accompanying illustration. It is essentially a belt-driven drop-hammer. A stone-cutting chisel is mounted on the anvil of

NUMBER OF GRANITE BLOCKS PRODUCED IN ONE 10-HOUR DAY BY 16 STONE CUTTING MACHINES

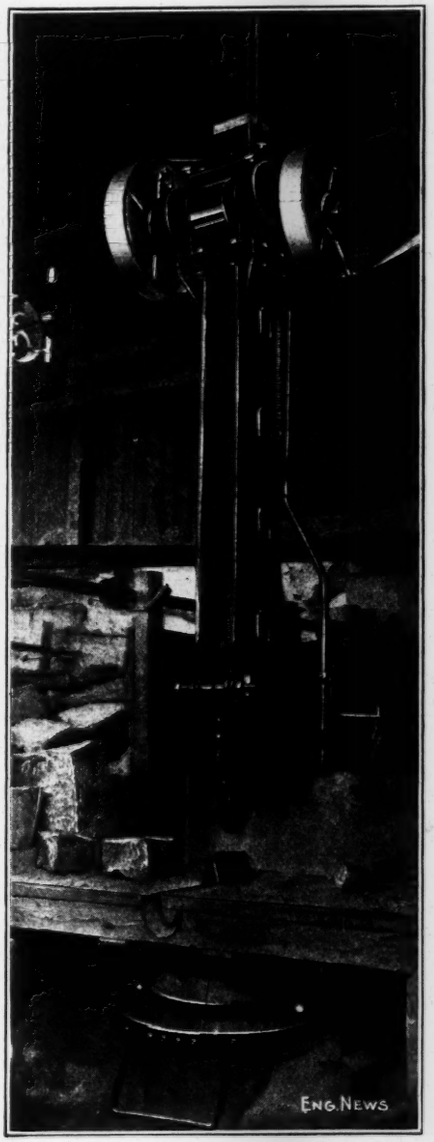
Machine number	Large blocks	Small Cubes: 2¾ to 3½-in.	Small Cubes: 4 to 4½-in.	Special sizes
1	129	270	100	125
2	207	275	325	136
3	151	413	500	190
4	186	500	425	150
5	18	682	118	100
6	76	230	250	250
7	75	200	200	159
8	200	600	500	180
9	279	450	....	100
10	115	360	500	130
11	154	560	276	200
12	100	444	305	105
13	70	180	55	52
14	63	208	223	61
15	149	400	470	73
16	126	450	525	183
16	2098	6222	4772	2194

the hammer and the hammer-head is shaped somewhat like that of a stone cutter's sledge. The chisel is mounted on the anvil in such a way that it can be conveniently removed for resharpening, which is necessary about two or three times a day. The hammer-head has to be touched up once every week or fortnight. The power required for each machine is about 1½ hp.

The stone supplied to the hammer should not exceed 12 to 13 in. in its smallest dimension and should not be too large for one man to handle easily. It is found best to have the stone cut in fairly regular rectangular blocks before bringing them to the machine. The operator lifts one of these blocks upon the chisel and strikes it a few light blows by partly raising the hammer in order to mark the block along the desired line of cleavage. He then raises the hammer to its full height and strikes the block a heavy blow to split it. It is claimed that one heavy blow is usually sufficient. It is most economical to make several different sizes of block at the same time so as to cut the stone with the least waste. The operator can then begin by splitting the stone along the line of its best cleavage and take advantage of the natural characteristics of each block. The mixed blocks are subsequently sorted by hand.

It is claimed that an intelligent laborer can soon learn to operate the machine so as to give an output of from five to seven tons per day of 10 hours. Much depends, however, upon the kind of stone, the care taken in shaping the blocks to rectangular form before sending them to the machine and on the skill of the operator. The accompanying table gives a record of the output of a battery of 16 of these machines during one 10-hour day.

About 400 machines of this type are in successful use in Europe, we are informed, and one concern in Sweden has 62 of them in use turning out about 700,000 sq.yd. of pavement per year. The agent for these machines in the United States is A. E. Sylven, 29 Broadway, New York City, to whom we are indebted for the foregoing description of the machine.



DROP HAMMER FOR CUTTING GRANITE CUBES FOR PAVING

Investigations on Rail Ingots*

SIZE OF INGOTS—A report by Mr. Wickhorst covers an investigation made at the South Works of the Illinois Steel Co., to throw light on the relationship of the size of ingots of bessemer rail steel to the segregation of the metalloids, locations of pipes and blow holes, and the properties of the rails. This investigation showed that under the conditions of the tests, the carbon, phosphorus and sulphur collected or segregated toward the interior and upper part of the ingot and that, in a general way, such segregation increased as the size of the ingot increased. The manganese also segregated, but to a much smaller extent, while the silicon showed little or no tendency to segregate.

The elements which segregated as described also showed a lowering in the top part of the ingot, below the average composition of the steel, and this lowering extended downward along the sides of the ingot. The "negative" segregation increased in general as the size of the ingot increased and also extended down further along the sides of the ingot. There was also a region of negative segregation in the interior and lower part of the ingot, but the lowering of the elements was not as great in this region.

This investigation also indicated that the material was distributed in the rail bar about the same, relatively, as it was in the ingot from which the rail bar had been rolled.

TESTS OF RAIL-STEEL INGOTS—The investigation at the Watertown Arsenal of rail-steel ingots and derivative shapes (as embodied in the Report of Tests of Metals, etc., made at the arsenal for the year 1909) indicated that the interior cavities of an ingot cooled directly after pouring are about the same or slightly less than in a similar ingot placed in the soaking pit and then cooled. This same result was also indicated as true of blooms subsequently made from such ingots.

It was shown that almost the full tensile strength and ductility of the metal of the lower part of the ingot were obtained rolling to about 10% of the original cross-section, but with the metal of the upper part of the ingot it was necessary to reduce the cross-section to 4% or less of the original amount.

A great many etchings were made and it was shown that the structure of the cross-section as developed by etching varies from the top to the bottom of the ingot and that each structure finds its counterpart in succeeding shapes and at about the same proportionate distance from the top end. It was also shown that the structure was considerably altered by changing the position in which the ingot was allowed to cool, as for instance allowing it to cool on its side after stripping.

INFLUENCE OF ROLLING TEMPERATURE—This report by Mr. Wickhorst covers an investigation made at the works of the Carnegie Steel Co. to determine the influence of the temperature of rolling on the properties of bessemer rails. This work indicated that the ductility and deflection in the drop test were influenced little, if at all, by the rolling temperature. The number of blows that it took to break the rails in the drop test was uninfluenced by the temperature of rolling. The yield point and the tensile strength in the tension tests were influenced little, if any. The elongation in the tension test decreased some as the temperature increased. The influence of temperature showed most prominently in the tension test, in the reduction of area, which decreased as the temperature of rolling increased. The size of the grain, as shown by the microscope, increased as the temperature increased.

The ductility in the drop test with the head of the rail in tension more nearly indicates the ductility of the interior metal as measured in the tension test, than does the ductility in the drop test with the base of the rail in tension, which arrangement is usual in inspection work.

*From the report of the Committee on Rails, presented at the annual meeting of the American Railway Engineering Association, at Chicago, Mar. 19-21. Mr. Wickhorst is engineer of tests for the committee.

Henry Wilson Spangler*

Prof. H. W. Spangler, Whitney Professor of Dynamical Engineering at the University of Pennsylvania, died at his home in Philadelphia, Penn., on Mar. 17, 1912, from heart disease, after a serious illness of several months. The first attack of this ailment befell him in the late summer of 1909, while alone, with the sole companionship of a guide, in the wilds of Maine. Upon partial recovery, he resumed his duties at the University, with characteristic determination, and against the protests of his friends, until the progress of his disease compelled him, three of four months ago, to relinquish all active duties.

Henry Wilson Spangler, son of John Kerr and Margaret Ann (Wilson) Spangler, was born at Carlisle, Penn., on Jan. 18, 1858. He was graduated with high rank at the United States Naval Academy, as Cadet Engineer, with the class of 1878. Two other members of that class have attained to prominent positions in the field of engineering education, namely, Prof. Ira N. Hollis, head of the Engineering Department at Harvard University, and Prof. M. E. Cooley, Dean of the Department of Engineering at the University of Michigan.

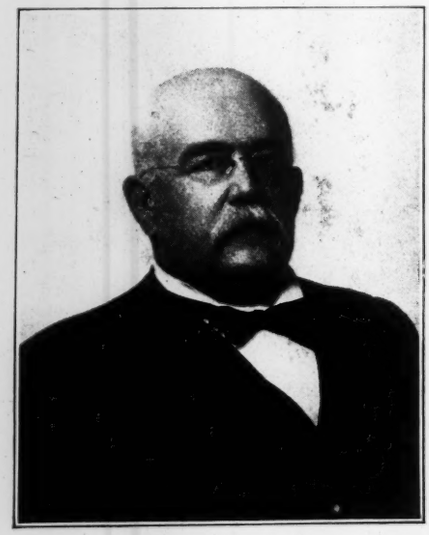
Prof. Spangler was Assistant Engineer in the United States Navy from 1878 to 1889, although for about half that period he was connected, on detached service, with the faculty of the University of Pennsylvania, first as Assistant Professor of Mechanical Engineering from 1881 to 1884, and from 1887 to 1889, and then as full professor, holding the Whitney Professorship of Dynamical Engineering. During the Spanish-American War in 1898, he served for a brief period as Chief Engineer in the United States Navy.

With the exception of that short interval, he was in the service of the University as the head of the Mechanical and Electrical Engineering Department continuously from 1887 till his death. The high standard of excellence to which this department has attained is due largely to his remarkable talents as a teacher, and his pronounced ability as an executive officer.

When he assumed his duties at the University the Department of Mechanical Engineering was housed in a single room on the third floor of College Hall, its equipment consisting only of a wooden model of a locomotive valve gear, and a Crosby indicator. A small laboratory, in which the principal features were a 5-hp. vertical boiler, and a 4x4-in. vertical engine, connected by belt to two dynamos, was afterward installed in the basement.

The establishment of a central lighting and heating plant by the University in 1891, afforded the desired opportunity of erecting, in connection therewith, a building devoted to instruction in Mechanical and Electrical Engineering. Within two years after its construction the number of students had increased to such an extent that the capacity of this modest building became overtaxed. That condition continued until the completion, in 1906, of the present Engineering Building, affording accommodations to all of the engineering departments of the University, in which the aggregate registration this year is 733.

Prof. Spangler was the author of a number of standard textbooks and numerous technical papers and professional reports. The textbooks from his pen embrace "Valve Gears" (1890); "Notes on Thermodynamics" (1901); "Elements of Steam Engineering," in collaboration with A. M. Greene and S. M. Marshall (1903);



H. W. Spangler.

"Graphics" (1908); and "Applied Thermodynamics" (1910). Of these books, "Valve Gears" has passed through two editions, "Notes on Thermodynamics" through five editions, and "Elements of Steam Engineering" is in its third edition.

As a writer, his chief characteristics were, perhaps, his painstaking efforts to present the subject in the simplest and clearest manner, consistent with the intended scope of treatment, and to keep in view the practical requirements of prospective engineers, rather than theorists.

As a teacher, he was lucid, stimulating, progressive, and always intensely practical. His first concern was to help the students to gain a firm grasp of the underlying principles of the subject, and then to encourage them to rely on their own resources in the application of these principles. On no point, perhaps, was he more insistent than that of individual responsibility, which his students were required to assume in every branch of their work.

In 1896, the University conferred upon him the honorary degree of Master of Science, and ten years later, the degree of Doctor of Science.

Prof. Spangler was a member of the American Society of Mechanical Engineers, the American Society of Naval Architects and Marine Engineers, the American Society for Testing Materials, the Society for the Promotion of Engineering Education (Charter Member, 1893; Member of Council, 1893-4; Vice-President, 1898-9), the Franklin Institute, and the Engineers' Club of Philadelphia (Director 1891-3, President 1890 and 1908). He was a member of the Advisory Council of the Engineering Congress at the World's Columbian Exposition in 1893 and of the Jury of Awards at the Buffalo Exposition in 1901. In 1908 he declined an invitation to accept the Directorship of Public Works of the City of Philadelphia.

The Engineers' Club of Philadelphia did him the signal honor of electing him to the presidency for the second time in 1908, which was the first occurrence of this kind in the long history of that organization. The Club had just entered upon a somewhat ambitious plan of expansion, including the acquisition of a modern club-house, at a heavy expense in proportion to its normal resources. In its quest for a man of the right qualities of leadership—at once, sound and progressive—during this critical period, the choice fell naturally upon Prof. Spangler, whose acceptance of the office meant inevitably its administration with the same self-sacrificing fidelity with which he met every responsibility that fell to his lot.

Endowed with quick initiative, resourcefulness, courage, and self reliance, his qualities of leadership stood out at their best at times of emergencies; such as the destruction by fire of the old Mechanical Engineering Building, and the almost immediate and orderly resumption of activities in an incomplete, new building, with such facilities as could be quickly improvised. A strict and almost military disciplinarian, he was no less rigid in the standards which he applied to himself. The respect and admiration in which he was held by his students ripened into affection as they came to see him at closer range. There were few graduates who failed to turn to him at some time for helpful counsel in the perplexities of later years, or who failed to accept it, even though it ran counter to their own promptings.

He possessed to a remarkable degree the faculty of perceiving clearly, and almost intuitively, the essential elements of a seemingly difficult problem or complex situation, and he was as quick in action as in perception. Few excelled him in the clear discernment of the fal-

*Contributed by request by Edgar Marburg, Professor of Civil Engineering, University of Pennsylvania.

lacies of an argument or in the directness of the challenge of such fallacies. Of a thoroughly progressive bent, he did not allow himself to be beguiled into strange paths by the educational fads and follies of the hour. The business of education was, to him, a serious business, with which liberties were not to be taken lightly.

Prof. Spangler was married to Nannie Jane Foreman, of Carlisle, Penn., on Dec. 1, 1881. Their union was blessed with three children, of whom one son, Henry Wilson Spangler, Jr., survives. Prof. Spangler's remains are interred in Carlisle, Penn.

Notes from Engineering Schools

UNIVERSITY OF NEBRASKA — "Engineers' Week" was celebrated beginning Mar. 4. All the engineering students wore badges which distinguished them from members of the other colleges. At a meeting on Mar. 5, Prof. O. V. P. Stout spoke on "The Development of the Engineering College," and a large picture of the former Dean, C. R. Richards, was presented by the honorary society, Sigma Tau. At an "engineers' rally" on Mar. 6, short talks were given on an engineer's life, in and out of college. On the next day, engineering students produced an issue of the *Daily Nebraskan* and the first issue of a semi-annual publication, the *Blue Print*. Mar 8 brought a department smoker and Mar. 9 a banquet.

Asphyxiation by Illuminating Gas caused the death of six inmates of the Huron County infirmary, near Norwalk, Ohio, Mar. 22. Eight others asleep in the same room were overcome but recovered. Reports state that the men were accustomed to sleep with all the windows tightly closed. The accident is ascribed to a temporary failure of the gas supply, which extinguished a burner left lighted.

A Coal Mine Explosion, in the mine of the San Bois Coal Co., at McCurtain, Okla., Mar. 20, caused the death of 85 to 90 men. The accident occurred shortly after 9 a.m., when 116 men were at work in the mine. Ten miners were rescued alive and the bodies of five others were recovered that night. On Mar. 21, 15 men were rescued alive who had barricaded themselves in a room on the 13th level, obtaining an air supply from the compressed-air line. On the same date, 50 dead bodies were removed from the mine, and on Mar. 22 the rescuers recovered 29 bodies.

An Explosion in the Coal Mine of the Jed Coal & Coke Co., at Jed, W. Va., Mar. 26, is reported to have killed 81 men. Eleven men at work near the foot of the shaft escaped in the cages, which were not damaged by the explosion, but one of them died within an hour, and these men were the only ones to reach the surface. The fan was damaged, but could still be operated so that rescuers were able to enter the mine immediately after the explosion. By night on the day of the disaster, 33 dead bodies had been found. Reports state that the barometric pressure in the vicinity had been unusually low for a week. The mine was inspected, Mar. 22, and pronounced safe.

An Explosion of Gas in the Cellar of a dwelling house at Dunmore, near Scranton, Penn., Mar. 20, and the fire which followed it completely demolished the building and caused the death of nine persons asleep in the house. A number of neighboring houses were damaged. The accident occurred between three and four o'clock in the morning. It is ascribed in press reports to the seepage of mine gas through crevices into the cellar, to be subsequently ignited by an oil lamp left burning in the kitchen. The Newark "News" ingeniously explains that the gas probably got into the mine fissures from a broken gas main.

The Strike of British Coal Miners, which began on Mar. 1, has caused greater suffering and loss in Great Britain than any other event occurring in many years. A large part of the country's manufacturing industries have shut down for lack of fuel, shipping is idle in all the ports and railway-train service has been greatly reduced to eke out the rapidly diminishing stock of railway fuel. The House of Commons passed a "minimum wage" bill applicable to the coal-mining industry, on Mar. 26, under which a minimum rate of wages for coal miners in each district is to be fixed by a Board for that district on which mine operators, miners and the government are each represented. The bill, however, is not satisfactory to the miners who insisted on a minimum wage being named in the bill applicable to the whole country.

The Harris & Blanck Prosecution ended last week, and the Triangle Shirt-Waist fire in New York City, a year ago, with its loss of some 150 lives thus goes finally into history. The proprietors of the factory, Isaac Harris and Max Blanck, were tried several months ago for criminal negligence, the death of one specific victim being charged; the trial centered around the charge that an exit door was kept locked. They were acquitted (Eng. News, Jan. 11, 1921), but several other indictments were still pending. When these were brought to trial, the judge ruled that the plea of former jeopardy barred further prosecution.

The U. S. Battleship "Maine," or rather the rear third of it which was recently raised from its resting place in Havana harbor and refloated, was towed out to deep water off the Cuban Coast and officially sunk, with fitting ceremonies, on Mar. 16. The human remains found among the wreckage were divided among 34 coffins and shipped to Washington, D. C., to be eventually interred at the National cemetery, at Arlington, Va. Memorial services were held at Washington, Mar. 23.

The "Maine" was originally sunk in Havana harbor, Feb. 15, 1898, by an explosion which shattered the forward two-thirds of the hull. A cofferdam was built around the wreck during the year 1911 and the water pumped out. The plan for this work was described in Engineering News, Oct. 20, 1910, and progress was noted in our issues of Feb. 2, Aug. 3, Sept. 7 and Nov. 9, 1911. The wreckage of the forward part of the hull was cut in pieces with acetylene torches so that none of it was left projecting high enough to interfere with navigation.

A Typhoid Outbreak at Two Harbors, Minn., is attributed to the pollution of the water supply by the sewage of the city—the city apparently using Lake Superior for both sewage disposal and water supply. The day the state board of health received notice of the outbreak it forwarded its portable hypochlorite plant to Two Harbors. In a bulletin issued by the state board for local instruction it is stated:

> At the present time there are but one or two convalescing patients in Two Harbors. Later on, however, those now sick will be recovering. It is most important to remember that such convalescent persons usually carry the germs in their bodies and throw them out in their discharges, just as the sick do, for an average period of three months after complete recovery. Hence a typhoid patient after recovery is nearly as dangerous as a sick person for the three next months; and all precautions proper for a sick person should be taken—such as disinfection of discharges, cleanliness of hands, etc. No typhoid convalescent should handle in any way the food or milk of other persons for at least three months after recovery. He should not milk, churn butter, handle raw groceries, bread or other food, cook, or wait on tables, etc.

The use of hypochlorite was begun at Two Harbors on Feb. 29. At that time about a hundred cases of typhoid had been reported.

A Joint Committee of Railway Officers and steel-rail manufacturers, organized to consider what can be done to make steel rails less liable to breakage and more durable, was held in New York City, on Mar. 21. The meeting was private, but an official statement was given out afterward which said:

> It was conceded that improvements can and ought to be made by both sides. Every reasonable effort will promptly be made in this direction. A subcommittee of six was appointed, three representatives of the railways and three of the steel manufacturers to consider the whole subject matter and report their conclusion and recommendation at a future meeting of the general committee to be called by the chairman.

Progress in Fabrication and Erection of the Panama Canal lock gates is reported as follows in the "Canal Record":

> At the Rankin, Penn., shops of the McClintic-Marshall Construction Co., contractors for the gates, a total of 25,663 tons of riveted material had been shipped by Jan. 20. This is a little over half the total contract, which amounts to 58,000 tons; 3000 tons additional of structural steel has been manufactured and inspected, but was delayed in shipment on account of unfavorable weather for painting. At the rolling mills 45,427 tons of structural steel had been accepted up to Jan. 20, or about 90% of the total. In the erection of the material on the Isthmus, it is stated that up to Feb. 1, 1912, 6646 tons of material had been erected, without regard to its being riveted or fully fitted. This is about 13% of the total steel to be erected. On the erection work a total of 330,000 field rivets had been driven up to Feb. 1 since the beginning of work out of a total of 5,500,000. Only 6% of the field riveting, therefore, has been completed.

The Cambridge Subway section of the Boston transit system was opened to traffic on Mar. 23, 1912. As described in our issue of Feb. 1, 1912, this subway extends from a terminal station under the Park St. station of the original or Tremont St. subway to Harvard Square, Cambridge. The portion in Boston is double-track arch tunnel, leading by a short elevated structure to the Cambridge Bridge over the Charles River. The bridge tracks are at roadway level, but occupy a reservation along the middle. The Cambridge portion, 2 miles long, is all two-track subway, with two intermediate stations at Kendall Square and Central Square, and an interchange terminal at Harvard Square for traffic

connection with underground loops of the Cambridge suburban trolley lines. The total length of the subway is about 3.2 mi., and the time of the trip is about 8 min. The first day of operation brought fairly heavy traffic.

A Sewage Testing Station at Cleveland, Ohio, has been authorized by the City Council. An appropriation of $20,000 has been made for construction purposes and plans are being prepared as rapidly as possible. It is expected that the station will be ready for use early in the summer of 1912. Experiments extending through a year will be made on clarification by screens and tanks and on sludge disposal, all on a larger scale than has previously been attempted at an experimental plant in this country. The plan is to treat 1,000,000 gal. of sewage a day. R. Winthrop Pratt, late chief engineer of the Ohio State Board of Health, is special engineer on sewage disposal at Cleveland, under Robert Hoffman, chief engineer of the Division of Engineering, Department of Public Service, and W. J. Springborn is director of the Department.

A National Commercial Organization is suggested in a circular sent out to local commercial organizations by the secretary of the Department of Commerce and Labor. A conference is to be held, Apr. 22, at Washington, D. C., to discuss the establishment of the proposed national organization. More than 150 local organizations have signified their approval of the plan and delegates to the conference have been appointed by 80 of these, including the San Francisco Chamber of Commerce, Chicago Association of Commerce, Boston Chamber of Commerce, Philadelphia Chamber of Commerce, New York Produce Exchange, National Association of Manufacturers, and the National Association of Cotton Manufacturers.

Extensive Contracts for Irrigation works were awarded by the South San Joaquin Irrigation District, of California, in February, 1912. We are indebted to Edwin Duryea (Humboldt Bank Building, San Francisco, Calif.) for the following statement regarding these and some earlier contracts let by the district named:

Bids were opened by the South San Joaquin Irrigation District, on Feb. 8, on Contract Divisions 2a, 2b, 3, 4 and 5. On Feb. 10 a contract for Divisions 2a and 2b was awarded to the Utah Construction Co. at an estimated total cost of $658,138. On Feb. 13 contracts for Divisions 3 and 5 were awarded to Mr. T. K. Beard, of Modesto, Calif., at estimated total amounts of $272,765 for No. 3 and $234,600 for No. 5. Also, on Feb. 13, the contract for the wooden flume, constituting Contract Division No. 4 was awarded to C. F. McCarthy, of the Pacific Construction Co.

The only remaining portions of the main canal between the head-works and the east edge of the South San Joaquin Irrigation District, were awarded to T. K. Beard last August. These portions are the diversion dam and head-works, Contract Division No. 1, estimated total cost about $147,000, and Contract Division No. 6, 6½ miles of unlined earth canal next to the district, with some structures, estimated total cost, $132,000.

The work on Contract Divisions Nos. 2 and 2a consists of about 2¾ miles of extremely heavy side-hill rock excavation in the Stanislaus River cañon and includes two 1000-ft. tunnels. All this portion of the work is the enlargement of an existing smaller ditch. Contract No. 2b consists of a new 2940-ft. tunnel, with about 2000 ft. of approaches. The material throughout these two contracts is generally hard slate and the capacity of the canal and tunnels will be 1370 cu.ft. sec. ultimately and 1110 in the beginning, 260 cu.ft. sec. of which will be water belonging to the Oakdale Irrigation District.

Contract No. 3 consists of about three miles of canal along a ridge in hardpan, with four short tunnels aggregating 960 ft. in length. The cuts are heavy and both the tunnels and open canal will be lined with concrete. The capacity of Contract No. 3 will be 1110 cu.ft. sec. ultimately and 860 in the beginning.

Contract No. 4 consists of a wooden flume 2000 ft. long and about 80 ft. maximum height, built for an ultimate capacity of 1110 cu.ft. sec. This flume crosses a saddle or break in the country.

Contract No. 5 consists of about five miles of partially side-hill and partially crest canal, with one tunnel 780 ft. in length. The canal is generally unlined and with an ultimate capacity of 1110 cu.ft. sec. and a present capacity of 860.

Contract Division No. 1, the dam and head-works, has already been constructed across the river span to a height of 12 ft. above low water and the north span of the arch dam is now being built. About 2½ miles of the canal in Contract Division No. 6 is already constructed.

Data on the Freezing of Water Mains and services during the past severe winter are wanted by F. A. Barbour, Tremont Building, Boston, Mass., chairman of the Committee on Depth of Water Pipe of the New England Water Works Association.

The Cornerstone of the New Hall of the London County Council (England) was laid on Mar. 9, by King George. After the ceremony the king knighted Maurice Fitzmaurice, chief engineer of the London County Council, and Edward White, chairman of the council. The site of the new county hall is near the Houses of Parliament, but on the opposite side of the river. The building will be 750 ft. long, will have an average width of 310 ft. and will be seven stories in height, with a commanding central tower or dome. The main axis will be nearly parallel with the Thames and one of the three facades will be parallel with and quite near the river, with no street intervening. The opposite facade extends along Belvedere Road. The third facade is on the Westminster Bridge approach, from which a wide covered driveway will extend well into the building to a large "members entrance court." The architect for the building is Ralph Knott, who will collaborate with W. E. Riley, architect to the County Council.

A Recording Gas Calorimeter has been invented by Mr. H. F. Smith, M. Am. Soc. M. E., of Lexington, Ohio. The apparatus consists of two parts, a sampling pump and the calorimeter proper. The sampling pump is arranged to supply the calorimeter with continuous samples of gas and air in a fixed volumetric ratio. The calorimeter consists of a nest or labyrinth of metal cylinders one within another. The gas and air mixture from the sampling pump enters the space between the two outermost cylinders and passes down around the lower edge of the second cylinder to the next space, then up over the top of the third cylinder to the third space and so on. At the center of the labyrinth, the gas and air mixture passes up through a burner tube.

The rise in temperature of the air and gas mixture, due to combustion, is taken as a measure of the heat value of the gas. The ratio of gas to air is so chosen as to make this assumption sufficiently correct. The temperature rise is recorded by a differential-expansion couple, one member of which is a thin steel tape which is subjected to the heated air from the burner while the other member is the outer tube of the calorimeter. The expansion of the steel tape moves, through a system of levers, the recording pen of the thermograph. Since the products of combustion leave the calorimeter at a high temperature, the low heat value is the one recorded.

The record is made on a circular disk chart graduated to read directly in B.t.u. The instrument is calibrated to read in terms of gas at 60° F. and 30-in. barometer. Since the sampling pump supplies gas and air in a fixed proportion regardless of changes in temperature or barometric pressure, correction for these changes is made automatically. The calorimeter is made by the Lexington Instrument Works, Lexington, Ohio, in two styles—one with a range of from 60 to 200 B.t.u. for producer and blast-furnace gas and the other from 200 to 1000 B.t.u. for richer gases.

Boiler Explosions in Great Britain are less numerous than in this country, according to the monthly "Bulletin" of the Fidelity & Casualty Co., of New York, for the reason that boiler accidents are investigated by a commission appointed by the British Board of Trade to fix the responsibility, and in practically all cases fines are assessed. As an example, the "Bulletin" mentions an accident at Manchester, England, in July, 1911, as follows:

The vessel which exploded was supplied by steam admitted through a reducing valve. Between the reducing valve and the vessel there was placed a steam gage, and the investigation disclosed that the foreman of the plant had some time prior to the accident removed this steam gage.

The responsibility for the explosion, therefore, was fixed upon the foreman who was promptly fined $100.

Experience with Diesel Oil Engines in marine service was reported in a Presidential Address by the Marquess of Graham before the Institute of Marine Engineers in London recently. The London "Times" of Feb. 14 summarizes the paper as follows:

He had personal experience of the Diesel oil engine of the Beardmore type, which had been installed in his yacht, the "Mairi." The engine fitted was a two-cycle engine of 130 b.-hp. at 350 r.p.m., with cylinders of 9-in. bore by 13-in. stroke. The fuel used had been crude Texas oil with a specific gravity of .9 to .93. He did not believe that the prime cost of installing oil engines need exceed the cost of steam engines and boilers. A quotation had been given for a complete oil engine marine installation of 600 hp. for less than £5000 [about $40 per hp.]. Oil could at present be bought at home ports for about 50s. a ton. Scottish shale oil was quite good for use in Diesel engines. A ship of 600 hp. sailing out of Glasgow supplied with crude Texas oil at 52s. per ton would show running costs of £8 6s. for a 24 hours' run. This would compare with £12 8s. with Welsh coal at 20s. a ton, and £8 19s. with Scotch coal at 14s. a ton. There would in the case of the oil engine be considerable economies in saving of labor, space and stand-by losses. The saving under the last-named head for a 3000-ton cargo boat running from Glasgow to Australian ports and back, via the Suez Canal, was estimated at the value of about 500 tons of coal.

With regard to the reversing of the marine oil engine he had carried out tests with his own yacht, and the average time taken to change over from full ahead to full astern was 9 sec. His yacht had been out in the Irish Sea and English Channel during the last six weeks, and no trouble had been experienced, either with racing or on account of the engine stopping when the propeller was being thrown in and out of the water.

Water-tight Underground Pipes—In discussing attempts at standardizing vitified sewer pipe, the London Contract Journal of Jan. 24 says:

"A casual observer, say from another planet, might easily suppose that the chief function of an underground pipe was to leak. Let the street be opened up in almost any modern city and the strong smell of gas testifies to the fact

that there is no small amount of leakage in gas pipes; yet it is no less the interest than the duty of gas engineers to make their pipes and joints permanently gas-tight. The leakage of water pipes is probably less in amount, save when they have been broken by frost; at any rate, it is less noticeable. But the leakage of sewer and drainage pipes has until lately been regarded as an inevitable evil, whether it be inward or outward. Textbooks and specifications often state the minimum allowable, but that minimum is startlingly large.

"It is only quite recently that sanitary engineers have dared to state that it is quite possible to make such pipes watertight at the joints, and even now there remains a doubt whether, though so made, they will stay watertight for any length of time. The British Engineering Standards Committee are even now engaged on the attempt to discover a convenient standard specification for the manufacture of vitrified ware pipes; and, the Institution of Municipal and County Engineers has produced for the consideration of the Standards Committee a draft specification."

Personals

Mr. W. G. Kirkpatrick, M. Am. Soc. C. E., a consulting engineer, of Jackson, Miss., has been appointed City Engineer, of Birmingham, Ala.

Mr. Tracy Bartholomew, formerly Manager of the Western Cement Products Co., Denver, Colo., has removed to San Juan, Porto Rico.

Mr. J. A. Gibson, a former master mechanic of the Cleveland, Cincinnati, Chicago & St. Louis Ry., has been appointed Superintendent of Steam Plants of the Illinois Traction System.

Mr. R. H. Thomson, M. Am. Soc. C. E., Port Engineer, and for several years previous City Engineer of Seattle, Wash., has resigned and will retire from active practice. Mr. Thomson is 56 years old and has been prominently identified with engineering undertakings in the Northwest since 1882.

Mr. J. B. Girand, former Territorial Engineer of Arizona, has associated with him Messrs. Carl E. Hasse and Frank R. Goodman, under the firm name of the Girand Engineering Co., for the general practice of engineering, with offices at 301 Fleming Block, Phoenix, Ariz.

Dr. M. Sengoku, M. Am. Soc. C. E., President of the Inamashura Co., a large hydro-electric project in Japan, and two of his associates are in this country to inspect the power developments at Niagara Falls and elsewhere, and to place orders for electrical equipment.

Mr. H. W. Durham, M. Am. Soc. C. E., has resigned his position as Resident Engineer of the Cape Cod Canal Construction Co., at Sandwich, Mass., to accept the appointment of Chief Engineer of the Bureau of Highways, Borough of Manhattan, New York City. Mr. Durham succeeds Gen. Theodore A. Bingham, who resigned in July, 1911.

Mr. C. W. P. Ramsey, Assoc. M. Can. Soc. C. E., has been appointed Engineer of Construction of the eastern lines of the Canadian Pacific Ry., at Montreal, Que. Mr. Ramsey has been in the engineering department of the Canadian Pacific Ry. for 14 years, and for the past seven years has been in the construction department.

Mr. Ray Palmer, Assoc. Am. Inst. E. E., a consulting engineer, of Chicago, Ill., has been appointed City Electrician of Chicago, succeeding Mr. William Carroll, resigned.

Mr. J. H. Taylor, General Superintendent of the Great Northern Ry., at Great Falls, Mont., has been transferred to Superior, Wis., succeeding Mr. D. M. Philbin, and Mr. C. O. Jenks, Division Superintendent at Great Falls, has been promoted to be General Superintendent, succeeding Mr. Taylor.

Mr. Frank D. Chase, Assoc. M. Am. Soc. C. E., Architect for the Western Electric Co., of Chicago, Ill., has opened offices in the Peoples Gas Bldg., Chicago, for the general practice of architecture and industrial engineering.

Mr. Selskar M. Gunn, Assistant Professor of Biology and Public Health at the Massachusetts Institute of Technology, has been chosen Secretary of the American Public Health Association and Managing Editor of its "Journal," succeeding Mr. W. C. Woodward, of Washington, D. C. Mr. Gunn will not relinquish his work at the Institute.

Mr. John Wilson, formerly Assistant City Engineer of Duluth, Minn., has been appointed City Engineer. Mr. Wilson is a graduate of the University of Wisconsin, class of 1903, and was for several years in railway work in New Mexico.

Sir William Lindley, M. Inst. C. E., of Frankfurt-am-Main, has been appointed Engineer-in-Chief of the Water Supply and Sewage Committee of the St. Petersburg (Russia) Town Council. He will have charge of the design and construction of water-works and a sewerage system to cost $50,000,000.

Mr. N. P. Turner, Assoc. M. Am. Soc. C. E., has resigned as Chief Engineer of the Cuba R.R., Camaguey, Cuba, and is now associated with Mr. L. D. Moore, M. Am. Inst. M. E., of New York. He will be engaged in mining, engineering and exploration work in the West Indies, Central and South America, with headquarters for the present at Camaguey, Cuba.

Mr. H. M. Waite, formerly Superintendent of the Seaboard Air Line Ry., at Birmingham, Ala., and more recently with the Clinchfield Coal Co. of Virginia, has been appointed City Engineer of Cincinnati, Ohio, succeeding Mr. H. F. Shipley, who has entered private practice in Cincinnati.

Mr. J. G. Shillinger, Division Engineer of Maintenance-of-Way of the Cleveland, Cincinnati, Chicago & St. Louis Ry., at Galion, Ohio, has been appointed Chief Engineer of the Rutland R.R., with headquarters at Rutland, Vt., succeeding Mr. J. C. Irwin, M. Am. Soc. C. E., resigned. Mr. Shillinger graduated from Cornell University in 1892 and entered the engineering department of the Cleveland, Cincinnati, Chicago & St. Louis Ry. in 1893 as an assistant to the engineer of maintenance-of-way of the Cleveland division.

Mr. A. R. Ayers, formerly Mechanical Engineer of the Lake Shore & Michigan Southern, the Indiana Harbor Belt and the Chicago, Indiana & Southern Rys., at Cleveland, Ohio, has been promoted to be General Mechanical Engineer of the New York Central Lines west of Buffalo, which is a newly created position. Mr. Ayers is a graduate of Cornell University, class of 1900, and entered upon railway work as a special apprentice with the Lake Shore & Michigan Southern Ry.

Dr. Harvey W. Wiley, whose resignation as Chief Chemist of the Department of Agriculture was noted in our issue of last week, will become Contributing Editor of "Good House Keeping Magazine" of New York City, on Apr. 1. This magazine has established and will maintain permanently at Washington, D. C., a Bureau of Foods, Sanitation and Health, of which Dr. Wiley will be in charge. Here, it is officially stated by the proprietors of the magazine, Dr. Wiley will have absolute freedom in an aggressive campaign to be waged against food adulteration and kindred abuses.

Mr. J. C. Stevens, Assoc. M. Am. Soc. C. E., a consulting hydraulic engineer of Portland, Ore., formerly District Engineer in charge of water-supply investigations of the United States Geological Survey in the Northwest, has accepted a position in connection with a large irrigation and water-power project near Barcelona, Spain, and sails from New York City on Mar. 28, to be gone several years. Mr. Stevens was graduated from the University of Nebraska in civil engineering, and has been Assistant State Engineer of Nebraska, Assistant Engineer of the United States Reclamation Service, and District Engineer of the United States Geological Survey. Since September, 1910, he has been engaged in private practice in Portland.

Sir Maurice Fitzmaurice, M. Inst. C. E., Chief Engineer of the London County Council, was knighted by King George IV on the occasion of the laying of the corner stone of the new County Hall, London, on Mar. 2. Sir Maurice Fitzmaurice was educated at Trinity College, Dublin, Ireland, and studied engineering in the office of the late Sir Benjamin Baker. He was an assistant engineer for Sir John Fowler and Sir Benjamin Baker in the construction of the Firth of Forth Bridge from 1884 to 1888. In 1892 he was Resident Engineer of the London County Council on the construction of the Blackwall tunnel under the River Thames. Later he was Chief Engineer for the Egyptian Government on the construction of the Assouan dam and reservoir on the River Nile. Since 1901 he has been Chief Engineer of the London County Council and has had charge of extensive rapid transit developments and of the duplication of the London main drainage system at a cost of about $20,000,000.

Obituary

John Lawrence Power O'Hanly, a civil engineer of Ottawa, Ont., died, on Mar. 22, aged 85 years. His early experience was gained on Canadian railway surveys. In 1872 he served as a commissioner for Ontario in the survey of the Ontario-Quebec boundary, and in 1881 he was engaged on the Ontario-Manitoba boundary survey.

Ralph Stockman Tarr, Professor and head of the department of geology at Cornell University, died, on Mar. 21, from hemorrhage of the brain. He was born at Gloucester, Mass., Jan. 15, 1864, and graduated from Harvard University in 1891, previous to which he had been with the United States Fish Commission and the United States Geological Survey. In 1892 he was appointed Assistant Professor of dynamic geology and physical geography at Cornell University, and in 1909 was placed at the head of the department. Besides his work here he was